ASC-TR-95-1004

MARK IIA AQUEOUS FILM FORMING FOAM (AFFF) PRECISION METERING SYSTEM PRODUCT EVALUATION TEST REPORT

Aeronautical Systems Center
Weapons, Air Base and Range Product Support Office
ASC/VXO
314 W. Choctawhatchee Ave., Ste. 104
Eglin AFB FL 32542-5717

August 1995

FINAL REPORT FOR PERIOD 16 DECEMER 1992 - 9 NOVEMBER 1994

AERONAUTICAL SYSTEMS CENTER
Air Force Materiel Command ■ United States Air Force ■ Eglin Air Force Base

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any employees, nor any of their contractors, subcontractors, or their employees, make any warranty, expressed or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any privately owned rights. Reference herein to any specific commercial product, process, or other service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency, contractor, or subcontractor thereof. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or any agency, contractor, or subcontractor thereof.

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise as in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This technical report has been reviewed by the Public Affairs Office (PA) and is approved for public release; distribution is unlimited.

This report has been reviewed and is approved for publication.

FOR THE COMMANDER

ROBERT RETTIE
Program Manager

Please do not request copies from the Aeronautical System Center, Weapons, Air Base and Range, Product Support Office (ASC/VXO). Address your request for additional copies to:

Defense Technical Information Center
8725 John J. Kingman Road
Ft Belvoir, VA 22060-6218

If your address has changed, if you wish to be removed from our mailing list, or if your organization no longer employs the addressee, please notify ASC/VXO, 314 W. Choctawhatchee Ave., Suite 104, Eglin AFB FL 32542-5717, email: RETTIE@EGLIN.AF.MIL, DSN 872-4697, ext.311, (904) 882-4697, ext. 311, to help us maintain a current mailing list.

Do not return copies of this report unless contractual obligations or notice on a specific document requires that it be returned.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1995	Final, 16 December 1992 - 9 November 1994

4. TITLE AND SUBTITLE
MARK IIA AQUEOUS FILM FORMING FOAM (AFFF) PRECISION METERING SYSTEM PRODUCT EVALUATION TEST REPORT

5. FUNDING NUMBERS

6. AUTHOR(S)
Bob Rettie, Wade H. Grimm, Stephen E. Kelley, Billy R. Dees

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Wright Laboratory
Airbase Fire Protection and Crash Rescue Systems (WL/FIVCF)
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Aeronautical System Center
Weapons, Air Base and Range, Product Support Office (ASC/VXO)
324 Choctawhatchee Ave., Suite 104
Eglin AFB, FL 32542-5717

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ASC-TR-95-1004

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*
Final report of the commercial technology exploitation evaluation of a computer controlled AFFF metering system produced by NORDIC Systems Inc. of Toronto, Canada. The initial evaluation was conducted by Wright Laboratory, Airbase Fire Protection and Crash Rescue Systems section at Tyndall AFB, Florida between 16 December 1992 and 25 June 1993. This initial evaluation used paddle wheels to determine liquid flow rates, but resulted in irregular concentrations of foam. A follow-on evaluation incorporating magnetic flow meters was conducted between 7 and 9 November 1994. The test evaluated foam concentrations of 1, 3 and 6 percent. The system met user requirements and has been recommended for retrofit onto Air Force P-19, P-23 and other front-line ARFF vehicles.

14. SUBJECT TERMS AQUEOUS FILM FORMING FOAM; AFFF; NORDIC SYSTEMS INC P-19; FOAM METERING; ARFF; WL/FIVCF

15. NUMBER OF PAGES
56

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOGRAPHS

ABBREVIATIONS/ACRONYMS/SYMBOLS

AFFF	AQUEOUS FILM FORMING FOAM
AFR	AIR FORCE REGULATION
ARA	APPLIED RESEARCH ASSOCIATES, INC.
ARFF	AIRCRAFT RESCUE AND FIREFIGHTING VEHICLE
Ao	OPERATIONAL AVAILABILITY
BDM	BDM MANAGEMENT SYSTEMS COMPANY
DOD	DEPARTMENT OF DEFENSE
DSN	DEFENSE SWITCHING NETWORK
gpm	GALLONS PER MINUTE
IAW	IN ACCORDANCE WITH
LTI	LIMITED TECHNICAL INSPECTION
MARK IIA	THE COMPUTERIZED FOAM PROPORTIONING SYSTEM (PRODUCED BY NORDIC SYSTEMS INC.)
MDT	MEAN DOWN TIME
MTBM	MEAN TIME BETWEEN MAINTENANCE
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
P-19	A/S32P-19 CRASH FIRE RESCUE VEHICLE
PMD	PROGRAM MANAGEMENT DIRECTIVE
RM&A	RELIABILITY, MAINTAINABILITY, AND AVAILABILITY
RTO	RESPONSIBLE TEST ORGANIZATION
WL/FIVCF	WRIGHT LABORATORY/ AIRBASE FIRE PROTECTION AND CRASH RESCUE SYSTEMS SECTION

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION I
PURPOSE AND BACKGROUND

1.0 **PURPOSE.** The purpose for this product evaluation was to examine an off-the-shelf aqueous film forming foam (AFFF) metering system for incorporation on Air Force Crash Fire Rescue Vehicles. This product evaluation was accomplished as part of a continuing effort to identify an AFFF system capable of metering foam accurately at 1%, 3% and 6% concentrations. The results of this evaluation will support a decision to apply the technology to Air Force firefighting apparatus. If applicable, the Department of Defense (DOD) could use the results of the evaluation for other firefighting vehicles.

1.1 **AUTHORIZING DIRECTIVES.** Authority for the Mark IIA system product evaluation is in PMD 8028(9), dated 10 May 1991. This evaluation was conducted as directed in AFR 80-14 and AFR 55-43.

1.2 **BACKGROUND.** The DOD currently uses AFFF concentrates formulated and mixed with water in ratios of 3 and 6 percent, using an around-the-pump proportioning system with fixed orifices. Common fire protection community terminology refers to an AFFF concentrate designed to be mixed with water at a ratio of 3% AFFF to 97% water as "**3% AFFF**". A "**6% AFFF**" concentrate contains approximately one-half of the surfactant and other active ingredients as **3% AFFF** concentrate per unit volume and, consequently, is referred to as "less concentrated". When mixed with water at their designed ratios, both types AFFF/water mixture are essentially the same. The newest commercial AFFF formulation is 1% concentrate which is increasingly being used by civilian firefighting facilities. By using **1.0% AFFF** concentrate (as compared to 3% and 6%), a considerable cost savings in shipping and storage can be achieved. Likewise, agent conservation, extended firefighting capability, and reduced environmental impact can be realized. Although the Air Force inventory is 3% AFFF, 6% foam concentrate was evaluated to provide system performance data when the Air Force must acquire 6.0% foam such as was done during Operation Desert Shield/Storm. To enhance the interoperability of Air Force firefighting equipment during contingency applications, an additional capability to use 1% AFFF is highly advocated.

1.3 **DESCRIPTION OF SYSTEM TESTED.** The Nordic Systems Inc. Mark IIA Computerized Foam Proportioning System (hereafter called the Mark IIA) is a computer controlled metering system that continually adjusts the foam flow to deliver the correct solution concentration. Nordic Systems Inc. personnel installed and calibrated the Mark IIA system on a WL/FIVCF P-19 firefighting vehicle and provided operator and maintenance training to evaluation participants. The Mark IIA system consists of: a computer, foam flow meter, solution flow meter, foam control valve, self-contained digital read-out unit, and associated wiring and electrical connectors. A follow-on test phase replaced the paddle wheel flow meters for water and AFFF with magnetic flow meters. The advantages of the magnetic flow meters are more consistent metering and higher maintenance reliability. The

Mark IIA computer program has been modified to meet current USAF objectives to provide foam in concentrates of 1%, 3%, and 6% at flow rates between 60 and 750 gallons per minute (GPM). The AFFF dispensing ratio of the Mark IIA system is switch selectable over a range of 0-6% AFFF by the operator from the cab of the vehicle. When the AFFF reservoir is refilled with foam concentrate, the vehicle operator can adjust the Mark IIA to match the AFFF concentration in the reservoir.

1.4 **TEST FORCE, LOCATION, DATES.** Wright Laboratory, Airbase Fire Protection and Crash Rescue Systems Section (FIVCF), managed this product evaluation to verify metering accuracy, operational effectiveness, and suitability of the Mark IIA. The initial evaluation was conducted by the Responsible Test Organization (RTO), WL/FIVCF, between 16 December 1992 and 25 June 1993, at Tyndall AFB, FL. The follow-on evaluation of the magnetic flow meters was conducted between 7 and 9 November 1994.

SECTION II
PRODUCT EVALUATION DESCRIPTION

2.0 **OBJECTIVES.** WL/FIVCF used the data collected to compare the AFFF metering accuracy of the Mark IIA with the orifice plate system currently employed on the P-19. The primary objective of this evaluation was to verify the AFFF metering accuracy and consistency of the Mark IIA system in the P-19 firefighting vehicle. This evaluation assessed the Mark IIA system performance, operational effectiveness, and suitability for use with the P-19.

2.0.1 Objective E-1. Assess the Mark IIA system/P-19 integration and vehicle modification procedures.

2.0.2 Objective E-2. Assess the operational performance of the Mark IIA system installed on the P-19.

2.0.3 Objective S-3. Assess the compatibility of the Mark IIA system installed on the P-19 with firefighting operations.

2.0.4 Objective S-4. Assess the adequacy of technical data provided with the Mark IIA system.

2.0.5 Objective S-5. Assess the Mark IIA system Reliability, Maintainability and Availability (RM&A).

2.1 **SCOPE AND METHOD OF ACCOMPLISHMENT.** Prior to modifying the P-19 vehicle with the Mark IIA system, the RTO demonstrated the AFFF metering accuracy of the existing orifice plate system for 1%, 3% and 6% AFFF. The performance baseline was established for comparison with the Mark IIA system. After the orifice plate system was baselined, the Mark IIA system was installed on the same P-19 vehicle and the same AFFF metering accuracy data was collected. At the conclusion of each foam percentage evaluations, the AFFF metering accuracies were measured using sight gauges to evaluate the repeatability of the Mark IIA system to consistently provide 1%, 3%, and 6% AFFF. When the magnetic flow meters were installed, their performance was verified by an in-line mechanical measuring meter.

The evaluation participants from FIVCF/ARA were task qualified firefighting and maintenance personnel. General firefighting practices and procedures as outlined in National Fire Protection Association Standard 412, Evaluating Aircraft Rescue and Foam Fire Fighting Equipment, were followed.

Mark IIA system reliability data are reported as mature system point data since the system is commercially available (off-the-shelf).

2.2 **PLANNING CONSIDERATIONS AND LIMITING FACTORS.** Only one A/S32P-19 Crash Fire Rescue Vehicle was modified for this test. The baseline metering performance of the P-19 examined 1%, 3% and 6% AFFF dispensing; however, manufactured orifice plates were available only for 3% and 6%. Former attempts to meter at 1% using an orifice plate were unsuccessful. For this test, WL/FIVCF//ARA fabricated a 1% orifice plate to establish a baseline for evaluating the Mark IIA system.

The paddle wheel flow transducer in the Mark IIA system used to measure the flow of foam is accurate between a minimum of 2.7 GPM and a maximum of 81 GPM. The magnetic flow meter used in the second phase of testing measures between 0.2 and 100 GPM. This means that during the first phase of testing, when using the bumper turret only with 1% AFFF, or when using the hand line only at 1% or 3% AFFF, the mixture will be slightly inaccurate. To more reliably measure the quantities of AFFF solution used in these cases, a small auxiliary tank was installed with a more precise measurement scale. This auxiliary tank was not in place during the baseline runs with the orifice plates.

SECTION III
EFFECTIVENESS AND SUITABILITY

3.0 **SUMMARY.** The Mark IIA system was evaluated as specified in the test plan. Data on system performance, operational effectiveness and suitability were recorded as point data due to the relatively short evaluation period. The P-19 vehicle water and AFFF tanks were calibrated. The P-19 and Mark IIA systems were serviced and prepared for use in accordance with applicable technical manuals. After preparation for use, the P-19 and Mark IIA systems were operated to dispense AFFF ten times from each turret/nozzle (roof, bumper, and handline) for 60 seconds with 1%, 3%, and 6% AFFF. After each dispensing operation, the water and AFFF tank quantities were recorded using fluid sight gauges on the vehicle to determine the amounts used. This was accomplished to compute the Mark IIA system metering accuracy and to determine repeatability with the various AFFF concentrations. In the second phase (with magnetic flow meter) each turret/nozzle was operated five times each. The handline was included to determine the Mark IIA's ability to accurately meter AFFF at low flow rates. Since the dispersal pattern is primarily determined by the turret/nozzle and has been previously established, this test evaluated only the mixture of foam concentrates. No dispersal patterns were measured or pit fires extinguished. Special attention was given to the Mark IIA system performance. Nordic Systems technicians assisted FIVCF personnel during the installation and calibration of the Mark IIA system in the P-19 evaluation vehicle. They performed a limited technical inspection (LTI) and functionally operated the Mark IIA modification prior to beginning the evaluation. FIVCF/ARA/BDM personnel compared the installed hardware and components to the technical data package provided by Nordic Systems Inc. to verify completeness. During initial test and calibration, the measurement accuracy for small quantities of foam was inconsistent. On 8 Mar 93, an auxiliary 10-gallon foam tank was added to the P-19 to provide a more precise measurement container for low foam rate delivery test events.

3.1 Objective E-1. Assess the Mark IIA system/P-19 integration and vehicle modification procedures.

3.1.1 Method. Nordic Systems technicians assisted FIVCF personnel in the installation and calibration of the Mark IIA system in the P-19 evaluation vehicle. They performed a limited technical inspection (LTI) and functionally operated the Mark IIA modification prior to beginning the evaluation. Nordic gathered performance data and modified the Mark IIA computer program to conform with the exhibited characteristics of the P-19 installation. FIVCF/ARA/BDM personnel compared the installed hardware and components to the technical data package provided by Nordic Systems Inc. to verify completeness.

3.1.2 Results and Conclusions. During the installation, pictured in Appendix C, some adjustments to the data package were necessary to reflect the actual parts and location of items on this model of the P-19. The computer metering program had to be updated once calibration runs were accomplished. The final data package accurately represents the procedures and techniques required to modify the P-19 with the Nordic Systems Inc. Mark IIA Computerized Foam Proportioning System.

3.1.3 Recommendations. None.

3.2 Objective E-2. Assess the operational performance of the Mark IIA system installed on the P-19.

3.2.1 Method. The P-19 vehicle water and AFFF tanks were calibrated following the Firefighting Vehicle Fluid Calibration Procedures in the test plan. The P-19 and Mark IIA systems were serviced and prepared for use in accordance with applicable technical manuals. The P-19 and Mark IIA systems were operated to dispense AFFF ten times from each turret/nozzle (roof, bumper, and handline) for 60 seconds with 1%, 3%, and 6% AFFF. After each dispensing operation, the water and AFFF tank quantities were recorded from fluid sight gauges on the vehicle to determine the amounts used. These readings were used to compute the Mark IIA system metering accuracy and repeatability with the various AFFF concentrations. The handline was included to determine the Mark IIA's accuracy at low flow rates. During dispensing operations, special attention was given to the Mark IIA system performance.

3.2.2 Results and Conclusions. The Mark IIA system on the P-19 fire truck performed excellently during all phases of the evaluation. Consistent performance was difficult at the low foam flow rates. More consistent measurements were achieved using the magnetic flow meters. Metering results are summarized in Table 1 and elaborated in Figures 1 through 3. When the magnetic flow meters were installed for the second phase, the computer control had to be modified, but time and field equipment did not allow optimizing the control system. The mixture was slightly rich for all magnetic flow meter performance. In the graphs of figures 1 through 3, the left group of results are for the baseline runs, the center group is the NORDIC IIA system with paddlewheel flow meters and the right hand group is performance with the magnetic flow meters. Operationally, when the foam tank is refilled with foam of a different concentration than had been previously dispensed, the ratio of foam dispensed can be changed from inside the vehicle cab by a single switch change, providing a real time read-out of foam concentration being delivered at the dispensing nozzle. Currently a change in foam concentration requires a change in the orifice plate, a nominal 1.5 hour procedure.

3.2.3 Recommendations. An accurate calibration of all components in a kit should be accomplished at the production facility. If recalibration is necessary after repair actions in the field, a procedure should be incorporated in the technical order.

Table 1
Average AFFF metering system performance

	1% AFFF	3% AFFF	6% AFFF
* Target Range	0.9 - 1.2	2.8 - 3.5 (2.8 - 4.0 Handline)	5.5 - 7.0 (5.5 - 8.0 Handline)
ROOF			
Baseline	1.1	3.8	6.7
Mark IIA	**1.0**	**3.1**	**6.4**
Magnetic Flow Meters	1.1	3.3	6.2
ROOF & BUMPER			
Baseline	1.1	3.8	6.5
Mark IIA	**0.9**	**3.1**	**6.1**
Magnetic Flow Meters	1.1	3.2	6.0
BUMPER			
Baseline	0.9	2.9	6.7
Mark IIA	**1.2**	**2.7**	**6.0**
Magnetic Flow Meters	1.2	3.5	6.8
HANDLINE			
Baseline	1.1	3.7	5.2
Mark IIA	**1.7**	**2.8**	**5.9**
Magnetic Flow Meters	2.1	3.6	6.8

* Target ranges for 3% and 6% AFFF have been established in NFPA Standard 412, the target range for 1% has not been established by NFPA but was introduced by applying criteria similar to the 3% and 6% ranges.

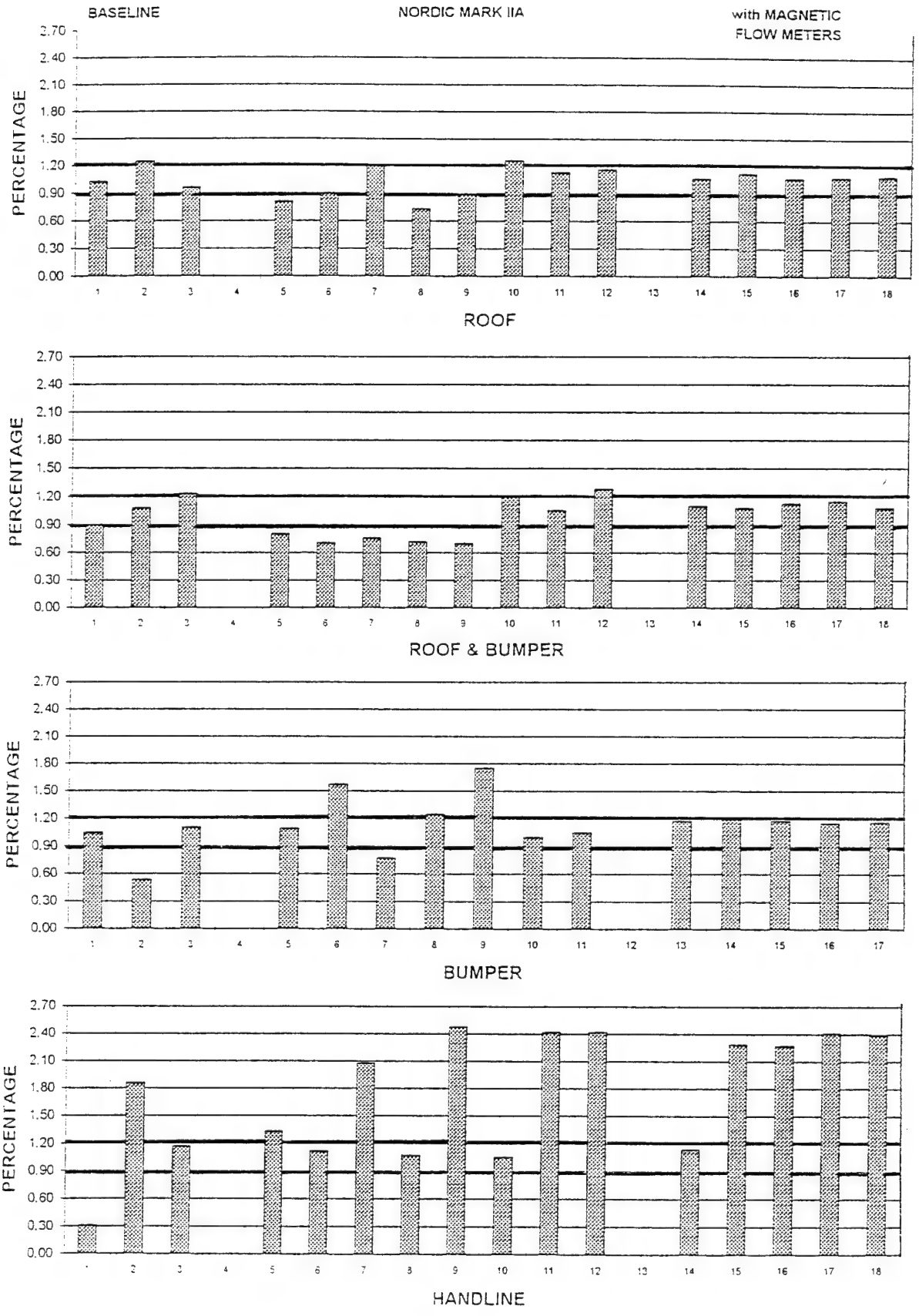


Figure 1

1% AFFF Performance

Target Range 0.9 - 1.2%

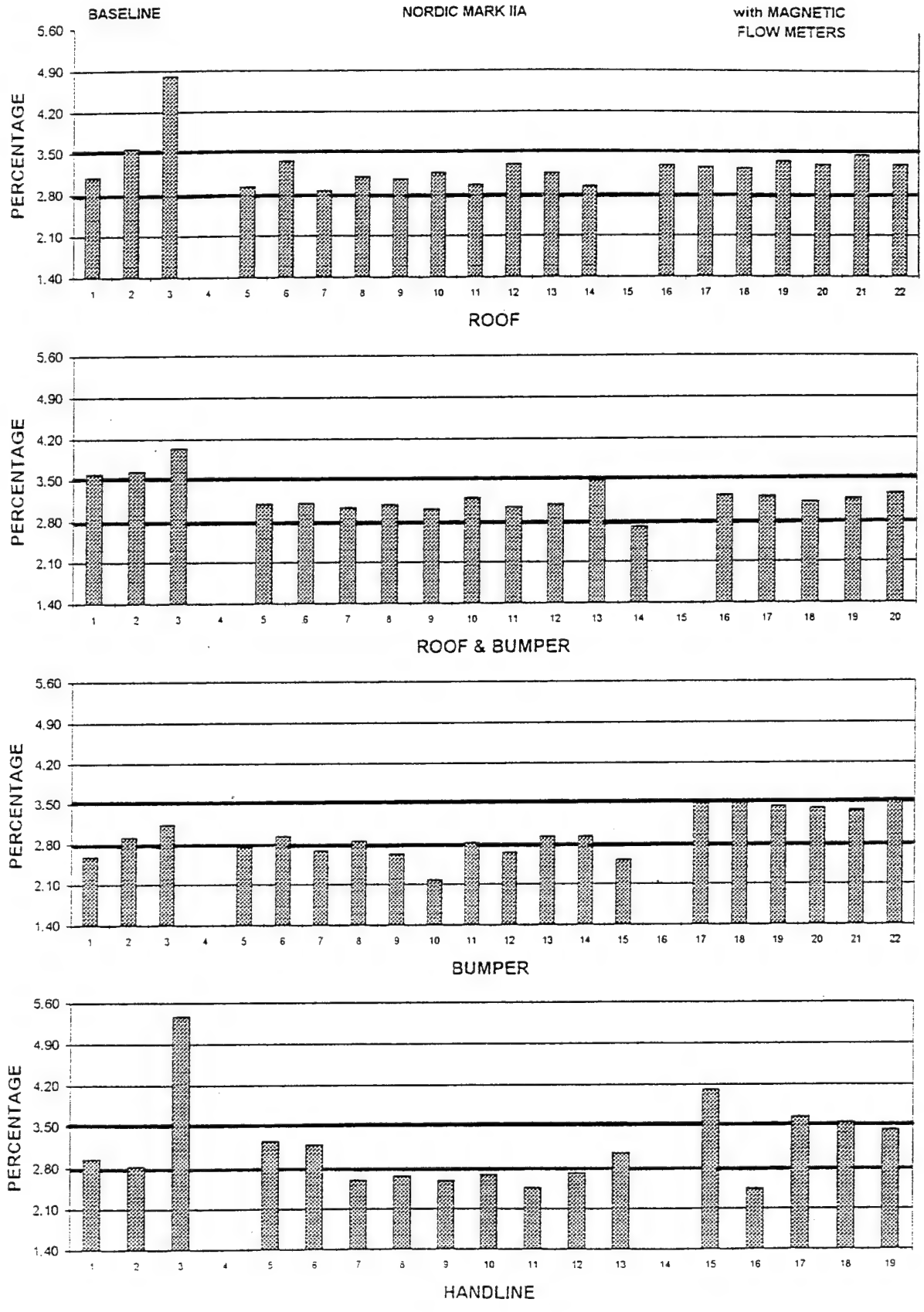


Figure 2

3% AFFF Performance

Target Range 2.8 - 3.5%

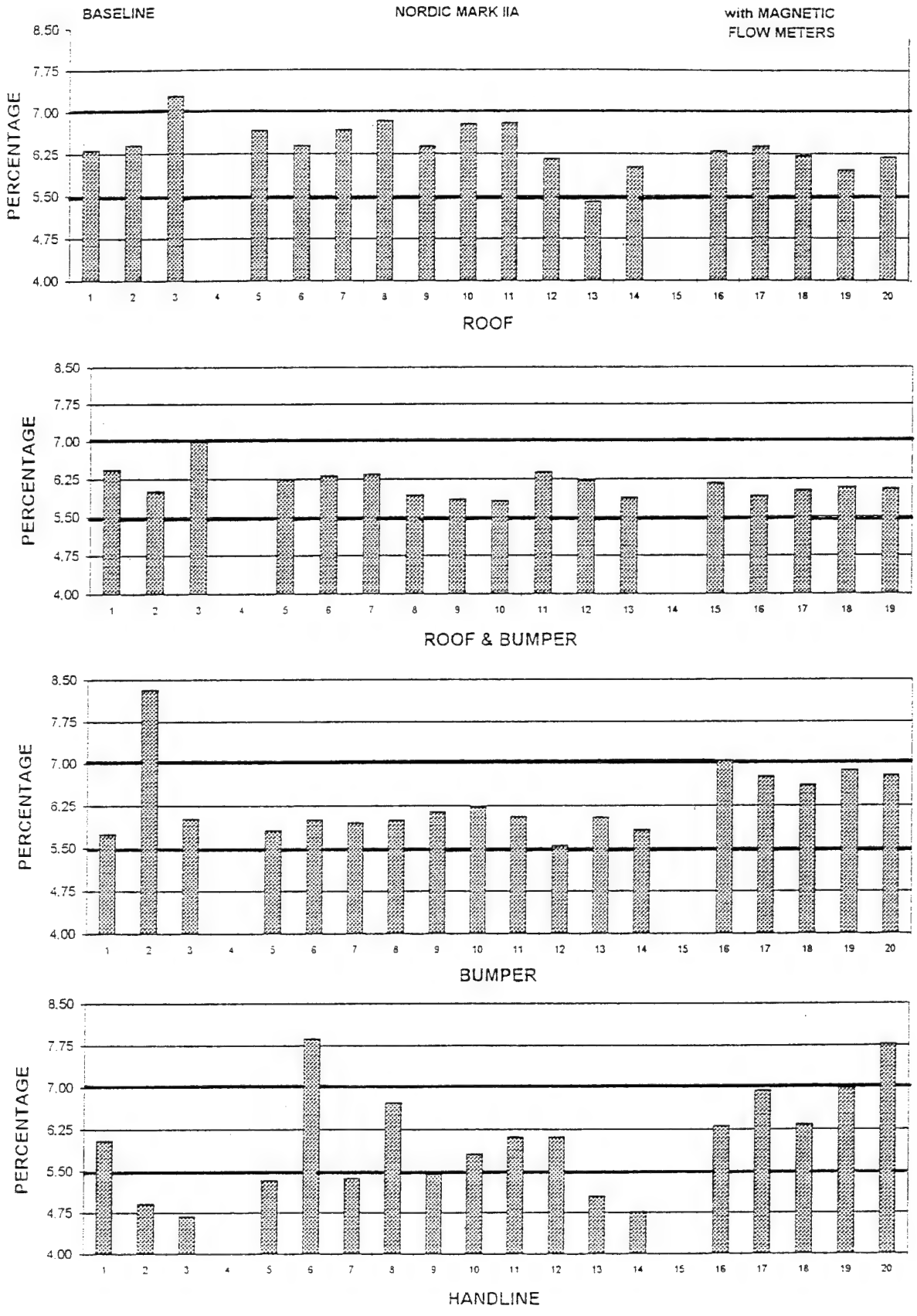


Figure 3
6% AFFF Performance
Target Range 5.5 - 7.0%

3.3 Objective S-3. Assess the compatibility of the Mark IIA system with the P-19 firefighting vehicle.

3.3.1 Method. The Mark IIA system was employed as described in the test plan and maintained IAW the operational concept and the manufacturer's technical data. The evaluation participants were briefed to be alert for any actual or foreseeable compatibility problems between and among the components and to notify the Evaluation Manager of any observed or experienced compatibility problems.

3.3.2 Results and Conclusions. No incompatibilities between the Mark IIA system and the P-19 fire truck were noted. Once the system was installed, changing to a different foam concentration required a single switch change instead of the nominal 1.5 hours previously required to change orifice plates. From a firefighters perspective, operations using the metering system were transparent to using the orifice plate system. With this type of metering system installed, the P-19 becomes more versatile due to its expanded capability to operate using 1% foam concentrate. The addition of this system makes the Air Force A/S32P-19 Crash Fire Rescue Vehicle or any other fire vehicle better suited for worldwide contingency operations using stockpiles of differing foam concentrations.

3.3.3 Recommendations. Investigate retrofit installation of a computerized metering system on all Air Force Fire/Crash Rescue vehicles that use AFFF as their primary firefighting agent.

3.4 Objective S-4. Assess the adequacy of the vendor provided technical manuals for the Mark IIA system.

3.4.1 Method. During this evaluation, participants used the vendor provided technical manuals. After each evaluation event, the participants indicated, on data forms and maintenance logs, any difficulties that prevented or hindered successful task performance. The Evaluation Manager recorded pertinent observations and comments in the Evaluation Manager's Log. The technical manual was reviewed and verified.

3.4.2 Results and Conclusions. During the installation, some adjustments to the data package were necessary to reflect the actual parts and location of items on this model of the P-19. The final data package accurately represents the procedures and techniques required. Operating instructions for the Nordic Systems Inc. Mark IIA Computerized Foam Proportioning System were clear and adequate for the necessary control settings and adjustments.

3.4.3 Recommendations. The next kit installed should serve as a kit proofing to verify that the data package is appropriate for base or depot level modification, depending upon where system installations will be accomplished.

3.5 Objective S-5. Assess the Mark IIA system Reliability, Maintainability, and Availability (RM&A).

3.5.1 Method. The Evaluation Manager and participants recorded any system failures and repair data. These data were to serve as the basis to calculate system point RM&A rates for the evaluation period.

3.5.2 Results and Conclusions. After the magnetic flow meters were installed, the computer controlled foam metering valve was operating erratically. The valve was replaced to provide accurate test results. This component was a manual valve that the contractor (NORDIC) had modified to be controlled by an electric motor. Since that phase of testing, the valve has been replaced by a commercially produced motorized valve made by Elkart. No system failures occurred during the evaluation period and no repairs were required. The first phase of test consisted of 32 hours of operation. The vehicle was in use for 16 months between phases and the system accumulated 56 hours of test operation by the conclusion of testing. This length of documented test operation is inadequate to provide any long term RM&A data. Mean Time Between Maintenance (MTBM) and Mean Down Time (MDT) could not be calculated since no records account for the amount of use during the 16 months between test phases. Operational Availability (Ao) was 100% during the periods of this evaluation.

3.5.3 Recommendations. If representative RM&A data are required, recommend a number of systems be installed in operational units and operated for a minimum of six months.

SECTION IV
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

4.0 Conclusions. During the installation, some adjustments had to be made to the plumbing and data package. The final data package outlines the requirements to modify the P-19 with the Mark IIA System. Consistent performance was difficult at the low foam flow rates. More consistent measurements were achieved by using magnetic flow meters. When the foam tank is refilled with foam of a different concentration than has been previously dispensed, the ratio of foam dispensed can be changed from inside the vehicle by a single switch change instead of the nominal 1.5 hours previously required to change orifice plates. A real time read-out of foam dispensing concentration is presented to the operator. No incompatibilities between the Mark IIA system and the P-19 fire truck were noted. From a firefighters perspective, operations using the metering system were transparent to using the orifice plate system. With this type of metering system installed, the P-19 becomes more versatile due to its expanded capability to operate using 1%, 3% and 6% foam concentrate. The addition of this system makes Air Force Crash Fire Rescue Vehicles better suited for worldwide contingency operations. Operating instructions for the Mark IIA were clear and adequate for the necessary control settings and adjustments. No system failures occurred during the evaluation period and no repairs were required. The test events, completed during 56 hour of operation, were inadequate to provide any long term RM&A data. Operational Availability (Ao) was 100% during the period of this evaluation.

4.1 Recommendations. Recommend that a computerized foam metering system be competitively procured for field and/or depot retrofit of P-19, P-23, and other front line ARFF vehicles. If a system calibration is required after field level repair, a procedure should be added to the technical order. If representative RM&A data is required, recommend a number of systems be installed in operational units and operated for a minimum of six months.

APPENDIX A

Table A-1
P-19 fluid tank calibration table

Water Tank		Fill	AFFF Tank		Auxiliary AFFF Tank	
Quantity Gallons	Depth in inches	Point	Quantity Gallons	Depth in inches	Quantity Gallons	Depth in inches
0	8	1	0	19	0	0
50	10 1/2	2	5	21 1/16	1	2 15/16
100	12 5/16	3	10	22 3/8	2	5 7/8
150	15 5/16	4	15	23 9/16	3	8 13/16
200	17 5/8	5	20	24 3/16	4	11 3/4
250	20	6	25	24 15/16	5	14 11/16
300	22 3/16	7	30	25 5/8	6	17 5/8
350	23 15/16	8	35	26 5/16	7	20 19/32
400	25 1/2	9	40	27 1/8	8	23 17/32
450	27 3/16	10	45	27 15/16	9	26 15/32
500	28 7/8	11	50	28 5/8	10	29 13/32
550	30 9/16	12	55	29 5/8	11	32 11/32
600	32 1/4	13	60	29 15/16	12	35 9/32
650	33 15/16	14	65	30 5/8		
700	35 9/16	15	70	31 3/8		
750	37 5/16	16	75	32		
800	39	17	80	32 5/8		
850	40 5/8	18	85	33 3/8		
900	42 1/4	19	90	34 1/16		
950	43 15/16	20	95	34 3/4		
1000	45 5/8	21	100	35 3/8		
		22	105	36 1/8		
		23	110	36 3/4		
		24	115	37 9/16		
		25	120	38 1/8		
		26	125	38 7/8		
		27	130	39 13/16		

APPENDIX A NORDIC MARK IIA EVALUATION MATRIX AND RESULTS

FIGURE GRAPH NO.	TEST NO.	TURRET	AFFF TANK	PLANNED DISPENSING TIME (sec)	ACTUAL DISPENSING TIME (sec)	WATER TANK INCHES START	WATER TANK INCHES END	WATER TANK GALLONS START	WATER TANK GALLONS END	AFFF TANK INCHES START	AFFF TANK INCHES END	AFFF TANK GALLONS START	AFFF TANK GALLONS END	WATER USED	AFFF USED	CALC. RATIO %
1-1	R 1-1	ROOF	AFFF	60	60.1	45.688	27.188	1001.370	450.000	31.625	30.813	72.000	66.250	551.370	5.750	1.03
1-2	R 2-1	ROOF	AFFF	60	60.2	32.531	8.938	608.333	18.750	30.063	29.313	60.909	53.438	589.583	7.472	1.25
1-3	R 3-1	ROOF	AFFF	60	60.2	45.688	29.313	1001.370	512.963	29.125	28.313	52.500	47.727	488.407	4.773	0.97
1-5	7	ROOF	AFFF	60	60.1	32.813	12.125	616.667	83.333	28.219	27.563	47.045	42.694	533.333	4.351	0.81
1-6	9	ROOF	AFFF	60	60.1	45.625	28.000	1000.000	474.074	26.500	25.813	36.154	31.365	525.926	4.789	0.90
1-7	14	ROOF	AFFF	60	60.2	43.438	25.938	935.185	412.963	24.813	23.906	24.169	17.752	522.222	6.417	1.21
1-8	16	ROOF	AFFF	60	60.1	45.531	28.156	997.222	478.704	27.313	26.688	41.155	37.308	518.519	3.847	0.74
1-9	18	ROOF	AFFF	60	60.5	45.625	28.094	1000.000	476.852	26.344	25.688	35.192	30.455	523.148	4.737	0.90
1-10	23	ROOF	AFFF	60	59.9	41.344	24.000	872.115	352.000	25.094	24.125	26.136	19.504	520.115	6.633	1.26
1-11	25	ROOF	AFFF	60	60.0	45.594	28.000	999.074	474.074	25.594	24.750	29.773	23.753	525.000	6.020	1.13
1-12	29	ROOF	AFFF	60	60.0	45.625	28.188	1000.000	479.630	26.156	25.313	33.866	27.727	520.370	6.139	1.17
2-1	R 1-3	ROOF	AFFF	60	60.0	45.688	26.500	1001.370	429.630	39.875	37.063	130.204	111.924	571.740	18.280	3.10
2-2	R 2-3	ROOF	AFFF	60	60.2	45.625	26.188	1000.000	420.370	30.625	27.688	65.000	43.464	579.630	21.536	3.58
2-3	R 3-3	ROOF	AFFF	60	60.2	45.688	26.344	1001.370	425.000	25.938	20.313	32.274	3.183	576.370	29.092	4.80
2-5	1	ROOF	AFFF	60	60.1	45.594	28.563	999.074	490.741	37.531	35.313	114.811	99.500	508.333	15.311	2.92
2-6	4/2	ROOF	AFFF	60	60.0	45.625	28.438	1000.000	487.037	34.250	31.813	91.364	73.500	512.963	17.864	3.37
2-7	4/3	ROOF	AFFF	60	60.2	32.875	12.750	618.519	96.154	39.563	37.281	128.669	113.271	522.365	15.397	2.86
2-8	5	ROOF	AFFF	60	65.0	45.625	26.313	1000.000	424.074	37.344	34.781	113.656	95.250	575.926	18.406	3.10
2-9	6	ROOF	AFFF	60	60.0	45.438	28.500	994.444	488.889	39.594	37.219	128.835	112.886	505.556	15.949	3.06
2-10	8	ROOF	AFFF	60	60.2	36.938	18.625	739.286	221.053	38.531	36.219	122.708	105.750	518.233	16.958	3.17
2-11	13/2	ROOF	AFFF	60	60.1	45.594	28.375	999.074	485.185	39.469	37.156	128.168	112.502	513.889	15.667	2.96
2-12	13/3	ROOF	AFFF	60	60.1	45.625	28.406	1000.000	486.111	33.969	31.594	89.321	71.750	513.889	17.571	3.31
2-13	18	ROOF	AFFF	60	60.3	43.344	26.281	932.407	423.148	36.094	33.813	104.792	88.184	509.259	16.608	3.16
2-14	20	ROOF	AFFF	60	60.1	45.625	28.469	1000.000	487.963	39.688	37.375	129.336	113.849	512.037	15.487	2.94
3-1	R 1-6	ROOF	AFFF	60	60.0	45.688	27.531	1001.370	460.185	39.281	34.156	127.168	90.682	541.185	36.486	6.32
3-2	R 2-6	ROOF	AFFF	60	60.2	45.688	27.000	1001.370	444.444	31.625	26.156	72.000	33.866	556.925	38.134	6.41
3-3	R 3-6	ROOF	AFFF	60	60.0	45.688	27.563	1001.370	461.111	36.375	30.563	107.000	64.545	540.259	42.455	7.29
3-5	1	ROOF	AFFF	60	60.1	45.500	28.875	996.296	500.000	39.719	34.625	129.502	94.091	496.296	35.411	6.66
3-6	5	ROOF	AFFF	60	60.0	43.406	26.688	934.259	435.185	39.219	34.438	126.834	92.727	499.074	34.107	6.40
3-7	8	ROOF	AFFF	60	60.0	43.500	26.969	937.037	443.519	39.312	34.344	127.335	92.045	493.519	35.289	6.67
3-8	13	ROOF	AFFF	60	60.1	45.500	28.875	996.296	500.000	39.188	34.094	126.668	90.227	496.296	36.440	6.84
3-9	15	ROOF	WATER	60	59.8	45.625	29.094	1000.000	506.481	39.563	34.750	128.669	95.000	493.519	33.669	6.39
3-10	16	ROOF	AFFF	60	60.0	45.625	28.906	1000.000	500.926	39.375	34.250	127.668	91.364	499.074	36.304	6.78
3-11	19	ROOF	AFFF	60	60.3	45.500	28.938	996.296	501.852	39.375	34.281	127.668	91.591	494.444	36.077	6.80
3-12	34	ROOF	WATER	60	60.0	45.625	29.031	1000.000	504.630	39.000	34.500	125.667	93.182	495.370	32.485	6.15
3-13	35	ROOF	WATER	60	60.0	45.625	27.063	1000.000	446.296	39.563	35.000	128.669	97.000	553.704	31.669	5.41
3-14	36	ROOF	AFFF	60	60.2	45.500	28.875	996.296	500.000	39.125	34.688	126.334	94.545	496.296	31.789	6.02
1-1	RB 1-1	ROOF/BUMP	AFFF	60	60.3	45.688	18.188	1001.370	211.842	27.969	26.813	45.227	38.077	789.528	7.150	0.90
1-2	RB 2-1	ROOF/BUMP	AFFF	60	60.1	45.688	18.875	1001.370	226.316	26.875	25.625	38.462	30.000	775.054	8.462	1.08
1-3	RB 3-1	ROOF/BUMP	AFFF	60	60.0	45.688	19.000	1001.370	228.947	25.750	24.375	30.910	21.251	772.422	9.659	1.24
1-5	3	ROOF/BUMP	AFFF	60	60.0	45.500	18.250	996.296	213.158	28.813	27.875	50.938	44.618	783.138	6.319	0.80
1-6	4	ROOF/BUMP	AFFF	60	60.1	45.594	18.219	999.074	212.500	27.906	27.000	44.811	39.231	786.574	5.580	0.70
1-7	5	ROOF/BUMP	AFFF	60	60.0	45.563	17.875	998.148	205.263	27.000	26.063	39.231	33.184	792.885	6.047	0.76
1-8	7	ROOF/BUMP	AFFF	60	60.0	45.625	18.000	1000.000	207.895	28.250	27.375	47.273	41.539	792.105	5.733	0.72
1-9	8	ROOF/BUMP	AFFF	60	60.0	45.625	18.000	1000.000	207.895	27.375	26.469	41.539	35.962	792.105	5.578	0.70
1-10	30	ROOF/BUMP	AFFF	60	60.1	45.344	17.750	991.667	202.632	25.375	24.000	28.182	18.503	789.035	9.679	1.21
1-11	31	ROOF/BUMP	AFFF	60	60.1	44.594	16.750	969.444	181.081	26.125	24.969	33.639	25.227	788.363	8.412	1.06
1-12	32	ROOF/BUMP	AFFF	60	60.0	44.969	17.500	980.556	197.297	24.906	23.469	24.795	14.607	783.258	10.188	1.28
2-1	RB 1-3	ROOF/BUMP	AFFF	60	60.1	45.625	16.438	1000.000	174.324	35.313	31.156	99.500	68.542	825.676	30.958	3.61
2-2	RB 2-3	ROOF/BUMP	AFFF	60	60.0	45.688	16.438	1001.370	174.324	33.563	29.625	86.365	55.000	827.046	31.365	3.65
2-3	RB 3-3	ROOF/BUMP	AFFF	60	60.1	45.250	17.875	988.889	205.263	27.750	22.563	43.849	10.790	783.626	33.059	4.05
2-5	9	ROOF/BUMP	AFFF	60	60.0	45.531	18.563	997.222	219.737	36.188	32.719	105.500	80.625	777.485	24.875	3.10
2-6	10/2	ROOF/BUMP	AFFF	60	60.3	45.500	19.094	996.296	230.921	36.281	32.875	106.250	81.667	765.375	24.583	3.11
2-7	10/3	ROOF/BUMP	AFFF	60	60.0	45.500	18.813	996.296	225.000	39.531	36.031	128.502	104.375	771.296	24.127	3.03
2-8	11/2	ROOF/BUMP	AFFF	60	60.1	45.594	19.031	999.074	229.605	38.656	35.250	123.542	99.000	769.469	24.542	3.09
2-9	11/3	ROOF/BUMP	AFFF	60	60.2	45.594	18.625	999.074	221.053	36.031	32.656	104.375	80.208	778.021	24.167	3.01
2-10	12/2	ROOF/BUMP	AFFF	60	60.0	45.594	18.625	999.074	221.053	35.281	31.813	99.250	73.500	778.021	25.750	3.20
2-11	12/3	ROOF/BUMP	AFFF	60	59.9	45.594	18.844	999.074	225.658	37.406	34.031	114.041	89.776	773.416	24.265	3.04
2-12	22	ROOF/BUMP	AFFF	60	60.0	45.625	19.125	1000.000	231.579	36.375	33.000	107.000	82.500	768.421	24.500	3.09
2-13	23	ROOF/BUMP	AFFF	60	60.0	45.625	18.875	1000.000	226.316	33.031	29.563	82.708	54.688	773.684	28.021	3.50
2-14	24	ROOF/BUMP	AFFF	60	60.1	45.313	18.844	990.741	225.658	29.563	26.094	54.688	33.412	765.083	21.276	2.71
3-1	RB 1-6	ROOF/BUMP	AFFF	60	60.3	45.000	15.313	981.481	150.000	30.438	21.438	63.636	6.429	831.481	57.208	6.44
3-2	RB 2-6	ROOF/BUMP	AFFF	60	60.2	45.688	16.500	1001.370	175.676	37.500	29.938	114.618	60.000	825.694	54.618	6.01
3-3	RB 3-6	ROOF/BUMP	AFFF	60	60.1	45.625	19.500	1000.000	239.474	31.313	22.938	69.583	12.369	760.526	57.214	7.00
3-5	10	ROOF/BUMP	AFFF	60	59.9	45.531	19.906	997.222	248.026	39.375	32.344	127.668	77.750	749.196	49.918	6.25
3-6	11	ROOF/BUMP	AFFF	60	60.0	45.625	20.000	1000.000	250.000	39.500	32.344	128.335	77.750	750.000	50.585	6.32
3-7	12	ROOF/BUMP	AFFF	60	60.0	45.469	19.906	995.370	248.026	39.500	32.343	128.335	77.744	747.344	50.591	6.34
3-8	13	ROOF/BUMP	WATER	60	60.1	45.625	19.563	1000.000	240.789	39.563	32.750	128.669	80.833	759.211	47.835	5.93
3-9	14	ROOF/BUMP	WATER	60	60.1	45.625	19.813	1000.000	246.053	39.688	33.000	129.336	82.500	753.947	46.836	5.85
3-10	15	ROOF/BUMP	WATER	60	60.2	45.625	19.562	1000.000	240.779	39.625	32.938	129.002	82.083	759.221	46.919	5.82
3-11	22	ROOF/BUMP	AFFF	60	60.0	45.625	20.188	1000.000	254.286	39.500	32.313	128.335	77.500	745.714	50.835	6.38
3-12	23	ROOF/BUMP	AFFF	60	60.1	45.625	20.125	1000.000	252.857	36.000	29.563	104.167	54.688	747.143	49.479	6.21
3-13	24	ROOF/BUMP	AFFF	60	60.0	45.500	24.250	996.296	360.000	29.813	23.969	58.005	18.253	636.296	39.752	5.88

ND RESULTS

AFFF TANK				WATER	AFFF	CALC. RATIO	TARGET RATIO	ERROR	FLOW RATE	AMB.	TEST	AFFF NORD CYLINDER	
INCHES		GALLONS										INCHES	
TART	END	START	END	USED	USED	%	%	%	(GPM)	TEMP	DATE	START	END
.625	30.813	72.000	66.250	551.370	5.750	1.03	1	0.03	556.2	56	18-Dec-92		
0.063	29.313	60.909	53.438	589.583	7.472	1.25	1	0.25	595.1	58	18-Dec-92		
.125	28.313	52.500	47.727	488.407	4.773	0.97	1	-0.03	491.5	65	18-Dec-92		
.219	27.563	47.045	42.694	533.333	4.351	0.81	1	-0.19	536.8	89	23-Jun-93		
.500	25.813	36.154	31.365	525.926	4.789	0.90	1	-0.10	529.8	80	24-Jun-93		
.813	23.906	24.169	17.752	522.222	6.417	1.21	1	0.21	526.9	81	24-Jun-93		
.313	26.688	41.155	37.308	518.519	3.847	0.74	1	-0.26	521.5	82	24-Jun-93		
.344	25.688	35.192	30.455	523.148	4.737	0.90	1	-0.10	523.5	83	24-Jun-93		
.094	24.125	26.136	19.504	520.115	6.633	1.26	1	0.26	527.6	83	24-Jun-93		
.594	24.750	29.773	23.753	525.000	6.020	1.13	1	0.13	531.0	84	24-Jun-93		
.156	25.313	33.866	27.727	520.370	6.139	1.17	1	0.17	526.5	86	20-May-93		
.875	37.063	130.204	111.924	571.740	18.280	3.10	3	0.03	590.0	74	16-Dec-92		
.625	27.688	65.000	43.464	579.630	21.536	3.58	3	0.19	599.2	74	16-Dec-92		
.938	20.313	32.274	3.183	576.370	29.092	4.80	3	0.60	603.5	69	17-Dec-92		
.531	35.313	114.811	99.500	508.333	15.311	2.92	3	-0.03	522.8	85	22-Jun-93		
.250	31.813	91.364	73.500	512.963	17.864	3.37	3	0.12	530.8	85	22-Jun-93		
.563	37.281	128.669	113.271	522.365	15.397	2.86	3	-0.05	536.0	82	23-Jun-93	0.002	0.002
.344	34.781	113.656	95.250	575.926	18.406	3.10	3	0.03	548.6	82	23-Jun-93		
.594	37.219	128.835	112.886	505.556	15.949	3.06	3	0.02	521.5	86	22-Jun-93		
.531	36.219	122.708	105.750	518.233	16.958	3.17	3	0.06	533.4	83	23-Jun-93		
.469	37.156	128.168	112.502	513.889	15.667	2.96	3	-0.01	528.7	83	22-Jun-93		
.969	31.594	89.321	71.750	513.889	17.571	3.31	3	0.10	530.6	86	23-Jun-93		
.094	33.813	104.792	88.184	509.259	16.608	3.16	3	0.05	523.3	82	22-Jun-93		
.688	37.375	129.336	113.849	512.037	15.487	2.94	3	-0.02	526.6	82	22-Jun-93		
.281	34.156	127.168	90.682	541.185	36.486	6.32	6	0.05	577.7	72	17-Dec-92		
.625	26.156	72.000	33.866	556.925	38.134	6.41	6	0.07	593.1	72	17-Dec-92		
.375	30.563	107.000	64.545	540.259	42.455	7.29	6	0.21	582.7	72	17-Dec-92		
.719	34.625	129.502	94.091	496.296	35.411	6.66	6	0.11	530.8	78	25-Jun-93		
.219	34.438	126.834	92.727	499.074	34.107	6.40	6	0.07	533.2	83	25-Jun-93		
.312	34.344	127.335	92.045	493.519	35.289	6.67	6	0.11	528.8	83	25-Jun-93		
.188	34.094	126.668	90.227	496.296	36.440	6.84	6	0.14	531.9	84	25-Jun-93		
.563	34.750	128.669	95.000	493.519	33.669	6.39	6	0.06	529.0	70	10-Mar-93	35.250	35.250
.375	34.250	127.668	91.364	499.074	36.304	6.78	6	0.13	535.4	84	25-Jun-93		
.375	34.281	127.668	91.591	494.444	36.077	6.80	6	0.13	527.9	84	25-Jun-93		
.000	34.500	125.667	93.182	495.370	32.485	6.15	6	0.03	527.9	81	19-May-93	28.688	28.688
.563	35.000	128.669	97.000	553.704	31.669	5.41	6	-0.10	585.4	81	19-May-93	28.688	28.688
.125	34.688	126.334	94.545	496.296	31.789	6.02	6	0.00	526.3	80	19-May-93		
.969	26.813	45.227	38.077	789.528	7.150	0.90	1	-0.10	792.7	66	18-Dec-92		
.875	25.625	38.462	30.000	775.054	8.462	1.08	1	0.08	782.2	67	18-Dec-92		
.750	24.375	30.910	21.251	772.422	9.659	1.24	1	0.24	782.1	68	18-Dec-92		
.813	27.875	50.938	44.618	783.138	6.319	0.80	1	-0.20	789.5	78	24-Jun-93		
.906	27.000	44.811	39.231	786.574	5.580	0.70	1	-0.30	790.8	78	24-Jun-93		
.000	26.063	39.231	33.184	792.885	6.047	0.76	1	-0.24	798.9	79	24-Jun-93		
.250	27.375	47.273	41.539	792.105	5.733	0.72	1	-0.28	797.8	79	24-Jun-93		
.375	26.469	41.539	35.962	792.105	5.578	0.70	1	-0.30	797.7	79	24-Jun-93		
.375	24.000	28.182	18.503	789.035	9.679	1.21	1	0.21	797.4	86	24-Jun-93		
.125	24.969	33.639	25.227	788.363	8.412	1.06	1	0.06	795.4	87	24-Jun-93		
.906	23.469	24.795	14.607	783.258	10.188	1.28	1	0.28	793.4	87	24-Jun-93		
.313	31.156	99.500	68.542	825.676	30.958	3.61	3	0.20	855.2	74	16-Dec-92		
.563	29.625	86.365	55.000	827.046	31.365	3.65	3	0.22	858.4	69	17-Dec-92		
.750	22.563	43.849	10.790	783.626	33.059	4.05	3	0.35	815.3	69	17-Dec-92		
.188	32.719	105.500	80.625	777.485	24.875	3.10	3	0.03	802.4	83	23-Jun-93		
.281	32.875	106.250	81.667	765.375	24.583	3.11	3	0.04	786.0	86	22-Jun-93		
.531	36.031	128.502	104.375	771.296	24.127	3.03	3	0.01	795.4	83	23-Jun-93		
.656	35.250	123.542	99.000	769.469	24.542	3.09	3	0.03	792.7	84	22-Jun-93		
.031	32.656	104.375	80.208	778.021	24.167	3.01	3	0.00	799.5	84	23-Jun-93		
.281	31.813	99.250	73.500	778.021	25.750	3.20	3	0.07	803.8	84	22-Jun-93		
.406	34.031	114.041	89.776	773.416	24.265	3.04	3	0.01	799.0	84	23-Jun-93		
.375	33.000	107.000	82.500	768.421	24.500	3.09	3	0.03	792.9	82	22-Jun-93		
.031	29.563	82.708	54.688	773.684	28.021	3.50	3	0.17	801.7	82	22-Jun-93		
.563	26.094	54.688	33.412	765.083	21.276	2.71	3	-0.10	785.1	82	22-Jun-93		
.438	21.438	63.636	6.429	831.481	57.208	6.44	6	0.07	884.3	50	18-Dec-92		
.500	29.938	114.618	60.000	825.694	54.618	6.01	6	0.00	877.4	50	18-Dec-92		
.313	22.938	69.583	12.369	760.526	57.214	7.00	6	0.17	816.4	50	18-Dec-92		
.375	32.344	127.668	77.750	749.196	49.918	6.25	6	0.04	800.4	83	25-Jun-93		
.500	32.344	128.335	77.750	750.000	50.585	6.32	6	0.05	800.6	84	25-Jun-93		
.500	32.343	128.335	77.744	747.344	50.591	6.34	6	0.06	797.9	84	25-Jun-93		
.563	32.750	128.669	80.833	759.211	47.835	5.93	6	-0.01	805.7	78	19-May-93		
.688	33.000	129.336	82.500	753.947	46.836	5.85	6	-0.03	799.5	78	19-May-93		
.625	32.938	129.002	82.083	759.221	46.919	5.82	6	-0.03	803.5	78	19-May-93		
.500	32.313	128.335	77.500	745.714	50.835	6.38	6	0.06	796.5	86	25-Jun-93		
.000	29.563	104.167	54.688	747.143	49.479	6.21	6	0.04	796.6	86	25-Jun-93		
.813	23.969	58.005	18.253	636.296	39.752	5.88	6	-0.02	811.3	84	25-Jun-93		

(2)

APPENDIX A NORDIC MARK IIA EVALUATION MATRIX AND RESULTS

FIGURE GRAPH NO.	TEST NO.	TURRET	AFFF TANK	PLANNED DISPENSING TIME (sec)	ACTUAL DISPENSING TIME (sec)	WATER TANK INCHES START	WATER TANK INCHES END	WATER TANK GALLONS START	WATER TANK GALLONS END	AFFF TANK INCHES START	AFFF TANK INCHES END	AFFF TANK GALLONS START	AFFF TANK GALLONS END	WATER USED	AFFF USED	CAL RATI %
1-1	B 1-1	BUMPER	AFFF	60	60.1	27.188	14.750	450.000	138.158	30.813	30.344	66.250	62.955	311.842	3.295	1.05
1-2	B 2-1	BUMPER	AFFF	60	60.0	23.938	12.438	350.000	89.744	29.313	29.031	53.438	52.031	260.256	1.406	0.54
1-3	B 3-1	BUMPER	AFFF	60	60.0	25.938	13.250	412.963	106.579	24.438	23.969	21.668	18.253	306.384	3.415	1.10
1-5	10	BUMPER	AFFF	60	60.0	28.000	17.937	474.074	206.568	25.813	25.406	31.365	28.409	267.495	2.956	1.09
1-6	15	BUMPER	AFFF	60	60.0	25.938	14.969	412.963	142.763	23.906	23.188	17.752	13.422	270.200	4.330	1.58
1-7	17	BUMPER	AFFF	60	60.0	28.156	18.000	478.704	207.895	26.688	26.344	37.308	35.192	270.809	2.115	0.78
1-8	19	BUMPER	AFFF	60	60.1	28.094	17.938	476.852	206.579	25.688	25.219	30.455	27.045	270.273	3.409	1.25
1-9	24	BUMPER	AFFF	60	60.0	24.000	12.188	352.000	84.615	24.125	23.500	19.504	14.739	267.385	4.765	1.75
1-10	26	BUMPER	AFFF	60	60.0	45.625	36.750	1000.000	733.929	26.906	26.469	38.654	35.962	266.071	2.692	1.00
1-11	27	BUMPER	AFFF	60	60.0	36.750	27.938	733.929	472.222	26.469	26.063	35.962	33.184	261.706	2.777	1.05
2-1	B 1-3	BUMPER	AFFF	60	60.3	26.188	12.969	420.370	100.658	27.688	26.313	43.464	35.000	319.712	8.464	2.58
2-2	B 2-3	BUMPER	AFFF	60	60.3	45.688	35.625	1001.370	701.786	36.125	34.875	105.000	96.000	299.584	9.000	2.92
2-3	B 3-3	BUMPER	AFFF	60	60.2	35.625	25.188	701.786	390.000	34.875	33.500	96.000	85.910	311.786	10.090	3.13
2-5	2	BUMPER	AFFF	60	60.1	28.563	18.969	490.741	228.289	35.313	34.344	99.500	92.045	262.451	7.451	2.76
2-6	3	BUMPER	AFFF	60	60.1	41.438	32.875	875.000	618.519	39.563	39.563	128.669	128.669	256.481	7.751	2.93
2-7	5	BUMPER	AFFF	60	60.0	28.438	18.750	487.037	223.684	31.813	30.813	73.500	66.250	263.353	7.250	2.68
2-8	6	BUMPER	AFFF	60	60.0	26.313	15.781	424.074	160.135	34.781	33.719	95.250	87.502	263.939	7.748	2.85
2-9	7/2	BUMPER	AFFF	60	60.1	28.500	18.750	488.889	223.684	37.219	36.219	112.886	105.750	265.205	7.136	2.62
2-10	7/3	BUMPER	AFFF	60	60.1	45.625	36.938	1000.000	739.286	39.531	38.531	128.502	122.708	260.714	5.794	2.17
2-11	14/2	BUMPER	AFFF	60	60.0	28.375	18.531	485.185	219.074	37.156	36.094	112.500	104.792	266.112	7.710	2.82
2-12	14/3	BUMPER	AFFF	60	60.0	28.406	18.625	486.111	221.053	31.594	30.563	71.750	64.545	265.058	7.205	2.65
2-13	17	BUMPER	AFFF	60	30.5	41.375	36.969	873.077	740.179	30.562	30.562	64.542	64.542	132.898	4.006	2.93
2-14	19	BUMPER	AFFF	60	60.0	26.281	15.719	423.141	158.784	33.813	32.656	88.184	80.208	264.357	7.976	2.93
2-15	21	BUMPER	AFFF	60	60.5	28.469	18.688	487.963	222.368	37.375	36.375	113.849	107.000	265.595	6.849	2.51
3-1	B 1-6	BUMPER	AFFF	60	60.2	27.531	15.500	460.185	154.054	34.156	31.625	90.682	72.000	306.131	18.682	5.75
3-2	B 2-6	BUMPER	AFFF	60	60.1	27.000	15.313	444.444	150.000	26.156	21.625	33.866	7.143	294.444	26.724	8.32
3-3	B 3-6	BUMPER	AFFF	60	60.0	27.563	15.313	461.111	150.000	30.563	27.875	64.545	44.618	311.111	19.927	6.02
3-5	2	BUMPER	AFFF	60	60.1	28.875	19.688	500.000	243.421	34.625	32.406	94.091	78.250	256.579	15.841	5.81
3-6	6	BUMPER	AFFF	60	60.0	26.688	16.750	435.185	181.081	34.438	32.188	92.727	76.500	254.104	16.227	6.00
3-7	8	BUMPER	WATER	60	60.1	29.031	19.375	504.630	236.842	34.500	32.156	93.182	76.250	267.788	16.932	5.95
3-8	9	BUMPER	AFFF	60	60.0	26.969	17.063	443.519	187.838	34.344	32.094	92.045	75.750	255.681	16.295	5.99
3-9	10	BUMPER	WATER	60	60.1	29.063	19.438	505.556	238.158	35.000	32.563	97.000	79.500	267.398	17.500	6.14
3-10	12	BUMPER	WATER	60	60.0	28.875	19.125	500.000	231.579	34.688	32.219	94.545	76.750	268.421	17.795	6.22
3-11	15	BUMPER	AFFF	60	60.0	26.844	16.875	439.815	183.784	34.063	31.813	90.000	73.500	256.031	16.500	6.05
3-12	17	BUMPER	AFFF	60	60.0	28.906	19.688	500.926	243.421	34.250	32.156	91.364	76.250	257.505	15.114	5.54
3-13	20	BUMPER	AFFF	60	60.1	28.938	19.719	501.852	244.079	34.281	32.000	91.591	75.000	257.773	16.591	6.05
3-14	28	BUMPER	AFFF	60	59.6	39.438	31.219	813.462	569.444	23.875	20.000	17.502	2.425	244.017	15.077	5.82
1-1	H 1-1	HANDLINE	AFFF	60	60.1	14.750	11.250	138.158	65.385	30.344	30.313	62.955	62.727	72.773	0.227	0.31
1-2	H 2-1	HANDLINE	AFFF	60	60.1	37.563	35.094	757.407	685.577	30.375	30.188	63.182	61.818	71.830	1.364	1.86
1-3	H 3-1	HANDLINE	AFFF	60	60.0	35.094	32.531	685.577	608.333	30.188	30.063	61.818	60.909	77.244	0.909	1.16
1-5	3	HANDLINE	AFFF	60	60.0	17.750	14.813	202.632	139.474	28.531	28.531	49.318	49.318	63.158	0.850	1.33
1-6	4	HANDLINE	AFFF	60	60.1	45.594	43.500	999.074	937.037	28.594	28.594	49.773	49.773	62.037	0.701	1.12
1-7	5	HANDLINE	AFFF	60	60.0	43.500	41.469	937.037	875.962	28.594	28.594	49.773	49.773	61.075	1.296	2.08
1-8	13	HANDLINE	AFFF	60	60.0	45.625	43.438	1000.000	935.185	24.813	24.813	24.169	24.169	64.815	0.701	1.07
1-9	20	HANDLINE	AFFF	60	60.0	17.000	14.063	186.486	123.684	25.094	25.094	26.136	26.136	62.802	1.594	2.47
1-10	21	HANDLINE	AFFF	60	60.1	45.563	43.375	998.148	933.333	25.094	25.094	26.136	26.136	64.815	0.691	1.05
1-11	22	HANDLINE	AFFF	60	60.2	43.375	41.344	933.333	872.115	25.093	25.094	26.136	26.136	61.218	1.519	2.42
1-12	28	HANDLINE	AFFF	60	60.0	27.938	25.813	472.222	409.259	26.063	26.062	33.184	33.180	62.963	1.562	2.42
2-1	H 1-3	HANDLINE	AFFF	120	120.1	15.250	8.188	148.684	3.750	35.813	35.188	102.917	98.500	144.934	4.417	2.96
2-2	H 2-3	HANDLINE	AFFF	60	60.2	13.250	9.625	106.579	32.500	30.813	30.500	66.250	64.091	74.079	2.159	2.83
2-3	H 3-3	HANDLINE	AFFF	60	61.2	12.969	9.344	100.658	26.875	26.313	26.000	35.000	32.729	73.783	2.271	5.38
2-5	1	HANDLINE	AFFF	60	60.0	45.625	43.438	1000.000	935.185	39.719	39.719	129.502	129.502	64.815	2.178	3.25
2-6	2	HANDLINE	AFFF	60	60.1	43.437	41.438	935.185	875.000	39.719	39.719	129.502	129.502	60.185	1.987	3.20
2-7	8	HANDLINE	AFFF	60	60.1	18.750	15.875	223.684	162.162	36.219	36.219	105.750	105.750	61.522	1.636	2.59
2-8	9	HANDLINE	AFFF	60	60.0	15.875	13.000	162.162	101.316	36.218	36.218	105.750	105.750	60.846	1.657	2.65
2-9	15/2	HANDLINE	AFFF	60	60.0	18.531	15.781	219.079	160.135	36.094	36.094	104.792	104.792	58.944	1.562	2.58
2-10	15/3	HANDLINE	AFFF	60	60.1	45.531	43.406	997.222	934.259	30.563	30.563	64.545	64.545	62.963	1.732	2.68
2-11	16/2	HANDLINE	AFFF	60	60.0	15.781	12.906	160.135	99.359	36.094	36.094	104.792	104.792	60.776	1.530	2.46
2-12	16/3	HANDLINE	AFFF	60	60.1	43.406	41.375	934.259	873.077	30.563	30.563	64.545	64.545	61.182	1.700	2.70
2-13	17	HANDLINE	AFFF	60	60.0	45.531	43.344	997.222	932.407	36.094	36.094	104.792	104.792	64.815	2.029	3.04
3-1	H 1-6	HANDLINE	AFFF	60	60.2	45.688	43.313	1001.370	931.481	32.063	31.500	75.500	71.000	69.888	4.500	6.05
3-2	H 2-6	HANDLINE	AFFF	60	60.0	43.313	40.938	931.481	859.615	31.500	30.969	71.000	67.292	71.866	3.708	4.91
3-3	H 3-6	HANDLINE	AFFF	60	60.0	40.938	38.500	859.615	785.185	30.969	30.438	67.292	63.636	74.430	3.655	4.68
3-5	3	HANDLINE	AFFF	60	60.1	19.688	16.875	243.421	183.784	32.406	32.406	78.250	78.250	59.637	3.357	5.33
3-6	4/5	HANDLINE	AFFF	60	59.9	45.531	43.406	997.222	934.259	39.594	39.219	128.835	126.834	62.963	5.380	7.87
3-7	4/1	HANDLINE	WATER	60	60.0	45.281	43.219	989.815	928.704	23.813	23.813	17.002	17.002	61.111	3.464	5.36
3-8	7	HANDLINE	AFFF	60	60.1	45.594	43.500	999.074	937.037	39.500	39.313	128.335	127.335	62.037	4.475	6.73
3-9	14	HANDLINE	AFFF	60	60.2	28.875	26.844	500.000	439.815	34.094	34.063	90.227	90.000	60.185	3.468	5.45
3-10	18	HANDLINE	AFFF	60	60.1	19.688	16.750	243.421	181.081	32.156	32.094	76.250	75.750	62.340	3.836	5.80
3-11	21	HANDLINE	AFFF	60	60.2	19.719	16.906	244.079	184.459	32.000	31.938	75.000	74.500	59.619	3.879	6.11
3-12	25	HANDLINE	AFFF	60	60.0	45.625	43.469	1000.000	936.111	23.906	23.813	17.752	17.002	63.889	4.161	6.11
3-13	26	HANDLINE	AFFF	60	60.1	43.469	41.438	936.111	875.000	23.875	23.875	17.502	17.502	61.111	3.241	5.04
3-14	27	HANDLINE	AFFF	60	60.1	41.438	39.438	875.000	813.462	23.875	23.875	17.502	17.502	61.538	3.071	4.75

AND RESULTS

AFFF TANK						CALC.	TARGET		FLOW			AFFF NORD CYLINDER	
INCHES		GALLONS		WATER	AFFF	RATIO	RATIO	ERROR	RATE	AMB.	TEST	INCHES	
START	END	START	END	USED	USED	%	%	%	(GPM)	TEMP	DATE	START	END
30.813	30.344	66.250	62.955	311.842	3.295	1.05	1	0.05	314.6	56	18-Dec-92		
29.313	29.031	53.438	52.031	260.256	1.406	0.54	1	-0.46	261.7	65	18-Dec-92		
24.438	23.969	21.668	18.253	306.384	3.415	1.10	1	0.10	309.8	68	18-Dec-92		
25.813	25.406	31.365	28.409	267.495	2.956	1.09	1	0.09	270.5	80	24-Jun-93		
23.906	23.188	17.752	13.422	270.200	4.330	1.58	1	0.58	274.5	81	24-Jun-93		
26.688	26.344	37.308	35.192	270.809	2.115	0.78	1	-0.22	272.9	82	24-Jun-93		
25.688	25.219	30.455	27.045	270.273	3.409	1.25	1	0.25	273.2	83	24-Jun-93		
24.125	23.500	19.504	14.739	267.385	4.765	1.75	1	0.75	272.1	83	24-Jun-93		
26.906	26.469	38.654	35.962	266.071	2.692	1.00	1	0.00	268.8	86	24-Jun-93		
26.469	26.063	35.962	33.184	261.706	2.777	1.05	1	0.05	264.5	86	24-Jun-93		
27.688	26.313	43.464	35.000	319.712	8.464	2.58	3	-0.14	326.5	74	16-Dec-92		
36.125	34.875	105.000	96.000	299.584	9.000	2.92	3	-0.03	307.0	69	17-Dec-92		
34.875	33.500	96.000	85.910	311.786	10.090	3.13	3	0.04	320.8	69	17-Dec-92		
35.313	34.344	99.500	92.045	262.451	7.451	2.76	3	-0.08	269.5	85	22-Jun-93		
39.563	39.563	128.669	128.669	256.481	7.751	2.93	3	-0.02	263.8	82	23-Jun-93	22.813	0.016
31.813	30.813	73.500	66.250	263.353	7.250	2.68	3	-0.11	270.6	85	22-Jun-93		
34.781	33.719	95.250	87.502	263.939	7.748	2.85	3	-0.05	271.7	82	20-May-93		
37.219	36.219	112.886	105.750	265.205	7.136	2.62	3	-0.13	271.9	86	22-Jun-93		
39.531	38.531	128.502	122.708	260.714	5.794	2.17	3	-0.28	266.5	83	23-Jun-93		
37.156	36.094	112.500	104.792	266.112	7.710	2.82	3	-0.06	273.8	83	22-Jun-93		
31.594	30.563	71.750	64.545	265.058	7.205	2.65	3	-0.12	272.3	86	23-Jun-93		
30.562	30.562	64.542	64.542	132.898	4.006	2.93	3	-0.02	269.3	86	23-Jun-93	24.750	12.969
33.813	32.656	88.184	80.208	264.357	7.976	2.93	3	-0.02	272.3	82	22-Jun-93		
37.375	36.375	113.849	107.000	265.595	6.849	2.51	3	-0.16	270.2	82	22-Jun-93		
34.156	31.625	90.682	72.000	306.131	18.682	5.75	6	-0.04	323.7	72	17-Dec-92		
26.156	21.625	33.866	7.143	294.444	26.724	8.32	6	0.39	320.6	72	17-Dec-92		
30.563	27.875	64.545	44.618	311.111	19.927	6.02	6	0.00	331.0	72	17-Dec-92		
34.625	32.406	94.091	78.250	256.579	15.841	5.81	6	-0.03	272.0	82	25-Jun-93		
34.438	32.188	92.727	76.500	254.104	16.227	6.00	6	0.00	270.3	83	25-Jun-93		
34.500	32.156	93.182	76.250	267.788	16.932	5.95	6	-0.01	284.2	81	19-May-93		
34.344	32.094	92.045	75.750	255.681	16.295	5.99	6	0.00	272.0	83	25-Jun-93		
35.000	32.563	97.000	79.500	267.398	17.500	6.14	6	0.02	284.4	81	19-May-93		
34.688	32.219	94.545	76.750	268.421	17.795	6.22	6	0.04	286.2	80	19-May-93		
34.063	31.813	90.000	73.500	256.031	16.500	6.05	6	0.01	272.5	84	25-Jun-93		
34.250	32.156	91.364	76.250	257.505	15.114	5.54	6	-0.08	272.6	84	25-Jun-93		
34.281	32.000	91.591	75.000	257.773	16.591	6.05	6	0.01	273.9	84	25-Jun-93		
33.875	20.000	17.502	2.425	244.017	15.077	5.82	6	-0.03	260.8	87	25-Jun-93		
30.344	30.313	62.955	62.727	72.773	0.227	0.31	1	-0.69	72.9	56	18-Dec-92		
30.375	30.188	63.182	61.818	71.830	1.364	1.86	1	0.86	73.1	58	18-Dec-92		
30.188	30.063	61.818	60.909	77.244	0.909	1.16	1	0.16	78.2	58	18-Dec-92		
28.531	28.531	49.318	49.318	63.158	0.850	1.33	1	0.33	64.0	87	23-Jun-93	30.000	27.500
28.594	28.594	49.773	49.773	62.037	0.701	1.12	1	0.12	62.6	89	23-Jun-93	27.625	25.563
28.594	28.594	49.773	49.773	61.075	1.296	2.08	1	1.08	62.4	89	23-Jun-93	25.563	21.750
24.813	24.813	24.169	24.169	64.815	0.701	1.07	1	0.07	65.5	81	24-Jun-93	29.625	27.563
25.094	25.094	26.136	26.136	62.802	1.594	2.47	1	1.47	64.4	83	24-Jun-93	27.625	22.938
25.094	25.094	26.136	26.136	64.815	0.691	1.05	1	0.05	65.4	83	24-Jun-93	22.875	20.844
25.093	25.094	26.136	26.136	61.218	1.519	2.42	1	1.42	62.5	83	24-Jun-93	20.844	16.375
26.063	26.062	33.184	33.180	62.963	1.562	2.42	1	1.42	64.5	86	24-Jun-93	16.313	11.719
35.813	35.188	102.917	98.500	144.934	4.417	2.96	3	-0.01	74.6	74	16-Dec-92		
30.813	30.500	66.250	64.091	74.079	2.159	2.83	3	-0.06	76.0	74	16-Dec-92		
26.313	26.000	35.000	32.729	73.783	2.271	5.38	3	0.79	74.6	74	16-Dec-92		
39.719	39.719	129.502	129.502	64.815	2.178	3.25	3	0.08	67.0	82	23-Jun-93	35.063	28.656
39.719	39.719	129.502	129.502	60.185	1.987	3.20	3	0.07	62.1	82	23-Jun-93	28.656	22.813
36.219	36.219	105.750	105.750	61.522	1.636	2.59	3	-0.14	63.1	86	22-Jun-93	35.313	30.500
36.218	36.218	105.750	105.750	60.846	1.657	2.65	3	-0.12	62.5	86	22-Jun-93	30.500	25.625
36.094	36.094	104.792	104.792	58.944	1.562	2.58	3	-0.14	60.5	83	22-Jun-93	34.344	29.750
30.563	30.563	64.545	64.545	62.963	1.732	2.68	3	-0.11	64.6	86	23-Jun-93	34.844	29.750
36.094	36.094	104.792	104.792	60.776	1.530	2.46	3	-0.18	62.3	83	22-Jun-93	29.750	25.250
30.563	30.563	64.545	64.545	61.182	1.700	2.70	3	-0.10	62.8	86	23-Jun-93	29.750	24.750
36.094	36.094	104.792	104.792	64.815	2.029	3.04	3	0.01	66.8	82	22-Jun-93	25.344	19.375
32.063	31.500	75.500	71.000	69.888	4.500	6.05	6	0.01	74.1	50	18-Dec-92		
31.500	30.969	71.000	67.292	71.866	3.708	4.91	6	-0.18	75.6	50	18-Dec-92		
30.969	30.438	67.292	63.636	74.430	3.655	4.68	6	-0.22	78.1	50	18-Dec-92		
32.406	32.406	78.250	78.250	59.637	3.357	5.33	6	-0.11	62.9	82	25-Jun-93	35.375	25.500
39.594	39.219	128.835	126.834	62.963	5.380	7.87	6	0.31	68.5	83	25-Jun-93	34.688	24.750
23.813	23.813	17.002	17.002	61.111	3.464	5.36	6	-0.11	64.6	74	21-May-93	35.063	24.875
39.500	39.313	128.335	127.335	62.037	4.475	6.73	6	0.12	66.4	83	25-Jun-93	35.438	25.219
34.094	34.063	90.227	90.000	60.185	3.468	5.45	6	-0.09	63.4	84	25-Jun-93	35.531	26.000
32.156	32.094	76.250	75.750	62.340	3.836	5.80	6	-0.03	66.1	84	25-Jun-93	35.250	25.438
32.000	31.938	75.000	74.500	59.619	3.879	6.11	6	0.02	63.3	84	25-Jun-93	35.313	25.375
23.906	23.813	17.752	17.002	63.889	4.161	6.11	6	0.02	68.1	87	25-Jun-93	35.063	25.031
23.875	23.875	17.502	17.502	61.111	3.241	5.04	6	-0.16	64.2	87	25-Jun-93	25.031	15.500
23.875	23.875	17.502	17.502	61.538	3.071	4.75	6	-0.21	64.5	87	25-Jun-93	15.500	6.469

APPENDIX A NORDIC MARK IIA EVALUATION MATRIX AND RESULTS

FIGURE GRAPH NO.	TEST NO.	TURRET	AGENT TANK	TARGET RATIO %	PLAN DISPENSING TIME (sec)	ACTUAL DISPENSING TIME (sec)	MECHANICAL METERED DATA					
							WATER USAGE - GALS			FOAM USAGE - GALS.		
							START	STOP	TOTAL USED	START	STOP	TOTAL USED
1-14	1	ROOF	AFFF	1	60	60.0	28,236	28,733	498	2,380.0	2,385.5	5.4
1-15	2	ROOF	AFFF	1	60	60.1	29,765	30,265	500	2,397.1	2,402.5	5.4
1-16	3	ROOF	AFFF	1	60	60.1	30,265	30,766	501	2,402.5	2,408.2	5.7
1-17	4	ROOF	AFFF	1	60	60.2	30,766	31,279	513	2,408.2	2,413.8	5.6
1-18	5	ROOF	AFFF	1	60	60.2	31,279	31,795	516	2,413.8	2,419.5	5.7
2-16	1	ROOF	AFFF	3	60	60.2	20,742	21,230	488	2,135.4	2,153.4	18.0
2-17	2	ROOF	AFFF	3	60	60.0	22,300	22,802	502	2,174.2	2,190.4	16.2
2-18	3	ROOF	AFFF	3	60	59.9	23,053	23,546	494	2,199.4	2,216.5	17.0
2-19	4	ROOF	AFFF	3	60	60.0	23,546	24,041	495	2,216.5	2,234.1	17.7
2-20	5	ROOF	AFFF	3	60	60.0	24,041	24,536	495	2,234.1	2,251.4	17.3
2-21	1A	ROOF	AFFF	3	60	60.4	18,216	18,735	519	2,045.8	2,063.6	17.8
2-22	3A	ROOF	AFFF	3	60	60.0	19,740	20,241	501	2,099.1	2,116.5	17.4
3-16	1	ROOF	AFFF	6	60	60.0	40,369	40,845	476	2,741.6	2,774.1	32.5
3-17	2	ROOF	AFFF	6	60	60.1	40,845	41,335	490	2,774.1	2,808.0	33.9
3-18	3	ROOF	AFFF	6	60	60.1	41,335	41,809	474	2,808.0	2,841.9	33.9
3-19	4	ROOF	AFFF	6	60	59.9	41,809	42,283	474	2,841.9	2,875.1	33.2
3-20	5	ROOF	AFFF	6	60	60.1	42,283	42,758	475	2,875.1	2,907.9	32.8
1-14	16	ROOF/BUMP	AFFF	1	60	60.0	28,993	29,765	772	2,388.4	2,397.1	8.7
1-15	17	ROOF/BUMP	AFFF	1	60	60.1	33,131	33,909	778	2,434.5	2,443.1	8.6
1-16	18	ROOF/BUMP	AFFF	1	60	60.1	33,909	34,683	774	2,443.1	2,452.1	9.0
1-17	19	ROOF/BUMP	AFFF	1	60	60.1	34,687	35,442	755	2,452.1	2,461.5	9.4
1-18	20	ROOF/BUMP	AFFF	1	60	60.2	35,442	36,208	766	2,461.6	2,470.4	8.8
2-16	17	ROOF/BUMP	AFFF	3	60	60.0	25,294	26,037	743	2,279.1	2,305.3	26.2
2-17	18	ROOF/BUMP	AFFF	3	60	59.9	26,037	26,757	720	2,305.3	2,329.8	24.5
2-18	19	ROOF/BUMP	AFFF	3	60	60.0	26,757	27,495	738	2,329.8	2,354.7	24.9
2-19	20	ROOF/BUMP	AFFF	3	60	60.2	27,495	28,236	741	2,354.7	2,380.0	25.3
2-20	2A	ROOF/BUMP	AFFF	3	60	60.0	18,984	19,740	756	2,072.8	2,099.1	26.3
3-15	16	ROOF/BUMP	AFFF	6	60	60.0	36,724	37,462	738	2,498.7	2,550.3	51.6
3-16	17	ROOF/BUMP	AFFF	6	60	59.9	37,462	38,179	717	2,550.3	2,598.5	48.2
3-17	18	ROOF/BUMP	AFFF	6	60	60.0	38,179	38,912	733	2,598.5	2,645.7	47.2
3-18	19	ROOF/BUMP	AFFF	6	60	60.1	38,912	39,643	731	2,645.7	2,693.5	47.8
3-19	20	ROOF/BUMP	AFFF	6	60	60.1	39,643	40,369	726	2,693.5	2,741.6	48.1
1-13	6	BUMPER	AFFF	1	60	60.1	28,733	28,993	260	2,385.5	2,388.4	3.0
1-14	7	BUMPER	AFFF	1	60	60.2	31,798	32,071	273	2,419.5	2,422.6	3.1
1-15	8	BUMPER	AFFF	1	60	60.1	32,071	32,333	262	2,422.6	2,425.6	3.0
1-16	9	BUMPER	AFFF	1	60	60.0	32,333	32,596	263	2,425.6	2,428.6	3.0
1-17	10	BUMPER	AFFF	1	60	60.1	32,596	32,863	267	2,428.6	2,431.6	3.0
2-17	7	BUMPER	AFFF	3	60	60.0	22,802	23,053	251	2,190.4	2,199.4	9.0
2-18	8	BUMPER	AFFF	3	60	60.1	24,536	24,791	255	2,251.5	2,260.5	9.0
2-19	9	BUMPER	AFFF	3	60	60.0	24,791	25,042	251	2,260.5	2,269.7	9.2
2-20	10	BUMPER	AFFF	3	60	60.1	25,042	25,294	253	2,269.7	2,279.1	9.4
2-21	4	BUMPER	AFFF	3	60	59.9	20,241	20,487	246	2,116.5	2,125.0	8.5
2-22	5	BUMPER	AFFF	3	60	60.1	18,735	18,984	249	2,063.6	2,072.8	9.2
3-16	6	BUMPER	AFFF	6	60	60.0	42,758	43,000	242	2,907.9	2,926.4	18.5
3-17	7	BUMPER	AFFF	6	60	59.9	43,000	43,238	238	2,926.4	2,944.1	17.8
3-18	8	BUMPER	AFFF	6	60	59.9	43,238	43,476	238	2,944.1	2,962.8	18.7
3-19	9	BUMPER	AFFF	6	60	59.9	43,476	43,720	244	2,962.8	2,981.4	18.6
3-20	10	BUMPER	AFFF	6	60	60.0	43,720	43,958	238	2,981.4	3,000.0	18.6
1-14	11	HANDLINE	AFFF	1	60	60.1	32,863	33,131	268	2,431.6	2,434.5	2.9
1-15	12	HANDLINE	AFFF	1	60	60.0	36,208	36,269	61	2,470.4	2,471.6	1.2
1-16	13	HANDLINE	AFFF	1	60	60.1	36,269	36,332	63	2,471.6	2,473.1	1.5
1-17	14	HANDLINE	AFFF	1	60	60.0	36,332	36,388	56	2,473.1	2,474.5	1.4
1-18	15	HANDLINE	AFFF	1	60	59.9	36,388	36,442	54	2,474.5	2,475.8	1.3
2-15	11	HANDLINE	AFFF	3	60	59.8	21,230	21,290	60	2,153.4	2,155.6	2.2
2-16	12	HANDLINE	AFFF	3	60	60.2	21,290	21,346	57	2,155.6	2,158.1	2.5
2-17	13	HANDLINE	AFFF	3	60	60.1	21,346	21,402	56	2,158.1	2,160.3	2.2
2-18	14	HANDLINE	AFFF	3	60	61.0	21,402	21,461	59	2,160.3	2,162.5	2.2
2-19	15	HANDLINE	AFFF	3	60	59.6	21,461	21,518	57	2,162.5	2,164.7	2.2
3-16	11	HANDLINE	AFFF	6	60	60.0	36,442	36,503	61	2,475.8	2,481.0	5.2
3-17	12	HANDLINE	AFFF	6	60	60.0	36,503	36,555	52	2,481.0	2,485.4	4.4
3-18	13	HANDLINE	AFFF	6	60	60.1	36,555	36,613	58	2,485.4	2,489.7	4.3
3-19	14	HANDLINE	AFFF	6	60	60.1	36,613	36,670	57	2,489.7	2,494.1	4.4
3-20	15	HANDLINE	AFFF	6	60	59.8	36,670	36,724	54	2,494.1	2,498.7	4.6

I MATRIX AND RESULTS

MAGNETIC FLOW METER DATA

MECHANICAL METERED DATA						ELECTRONIC METERED DATA							
	FOAM USAGE - GALS.			CALC RATIO %	ERROR %	SOLUTION USAGE - GALS			FOAM USAGE - GALS.			CALC RATIO %	ERROR %
AL ED	START	STOP	TOTAL USED			START	STOP	TOTAL USED	START	STOP	TOTAL USED		
8	2,380.0	2,385.5	5.4	1.08	0.08	57,156.9	57,653.8	503.0	6,166.7	6,171.9	5.38	1.07	0.07
0	2,397.1	2,402.5	5.4	1.07	0.07	58,671.5	59,172.4	507.0	6,183.7	6,189.2	5.66	1.12	0.12
1	2,402.5	2,408.2	5.7	1.12	0.12	59,172.4	59,673.9	507.6	6,189.5	6,194.7	5.43	1.07	0.07
3	2,408.2	2,413.8	5.6	1.08	0.08	59,673.9	60,174.8	507.1	6,195.1	6,200.5	5.48	1.08	0.08
6	2,413.8	2,419.5	5.7	1.09	0.09	60,174.8	60,680.5	511.8	6,200.7	6,206.1	5.59	1.09	0.09
8	2,135.4	2,153.4	18.0	3.56	0.56	49,524.0	50,031.3	513.4	5,921.4	5,938.1	16.91	3.29	0.29
2	2,174.2	2,190.4	16.2	3.13	0.13	51,074.0	51,579.0	511.1	5,964.0	5,980.5	16.68	3.26	0.26
4	2,199.4	2,216.5	17.0	3.34	0.34	51,834.3	52,335.3	507.1	5,989.9	6,006.2	16.44	3.24	0.24
5	2,216.5	2,234.1	17.7	3.44	0.44	52,335.3	52,840.9	511.7	6,006.5	6,023.5	17.20	3.36	0.36
5	2,234.1	2,251.4	17.3	3.38	0.38	52,840.9	53,343.0	508.2	6,023.7	6,040.4	16.82	3.31	0.31
9	2,045.8	2,063.6	17.8	3.32	0.32	46,944.4	47,483.8	545.5	5,831.0	5,849.8	18.93	3.47	0.47
1	2,099.1	2,116.5	17.4	3.36	0.36	48,495.3	49,007.9	518.7	5,884.2	5,901.2	17.17	3.31	0.31
6	2,741.6	2,774.1	32.5	6.39	0.39	69,371.2	69,877.8	512.7	6,518.7	6,550.9	32.32	6.30	0.30
0	2,774.1	2,808.0	33.9	6.47	0.47	69,887.8	70,393.4	511.7	6,551.0	6,583.6	32.69	6.39	0.39
4	2,808.0	2,841.9	33.9	6.67	0.67	70,393.4	70,906.0	518.8	6,583.9	6,615.9	32.20	6.21	0.21
4	2,841.9	2,875.1	33.2	6.55	0.55	70,906.0	71,409.0	509.0	6,616.3	6,646.4	30.31	5.95	-0.05
5	2,875.1	2,907.9	32.8	6.46	0.46	71,409.0	71,916.4	513.6	6,648.7	6,680.3	31.76	6.18	0.18
2	2,388.4	2,397.1	8.7	1.11	0.11	57,910.3	58,671.5	767.4	6,175.3	6,183.6	8.43	1.10	0.10
8	2,434.5	2,443.1	8.6	1.09	0.09	61,959.4	62,727.3	774.1	6,221.7	6,229.9	8.36	1.08	0.08
4	2,443.1	2,452.1	9.0	1.15	0.15	62,727.3	63,494.5	773.3	6,230.0	6,238.6	8.74	1.13	0.13
5	2,452.1	2,461.5	9.4	1.23	0.23	63,496.5	64,263.8	767.3	6,239.3	6,248.0	8.79	1.15	0.15
6	2,461.6	2,470.4	8.8	1.14	0.14	64,263.8	65,034.2	776.5	6,248.3	6,256.5	8.36	1.08	0.08
3	2,279.1	2,305.3	26.2	3.41	0.41	54,116.9	54,878.9	768.0	6,068.0	6,092.7	24.91	3.24	0.24
0	2,305.3	2,329.8	24.5	3.29	0.29	54,878.9	55,633.2	760.4	6,092.8	6,117.1	24.40	3.21	0.21
8	2,329.8	2,354.7	24.9	3.26	0.26	55,633.2	56,390.8	767.3	6,117.4	6,141.2	23.96	3.12	0.12
1	2,354.7	2,380.0	25.3	3.30	0.30	56,390.8	57,156.9	772.2	6,141.4	6,165.8	24.53	3.18	0.18
6	2,072.8	2,099.1	26.3	3.36	0.36	47,737.9	48,495.3	763.5	5,859.3	5,884.1	24.89	3.26	0.26
8	2,498.7	2,550.3	51.6	6.53	0.53	65,540.2	66,311.1	777.0	6,285.0	6,332.7	47.91	6.17	0.17
7	2,550.3	2,598.5	48.2	6.30	0.30	66,311.1	67,072.2	767.1	6,332.9	6,378.1	45.35	5.91	-0.09
3	2,598.5	2,645.7	47.2	6.05	0.05	67,072.2	67,835.9	769.8	6,379.3	6,425.5	46.32	6.02	0.02
1	2,645.7	2,693.5	47.8	6.14	0.14	67,835.9	68,604.6	767.3	6,425.5	6,472.1	46.68	6.08	0.08
6	2,693.5	2,741.6	48.1	6.21	0.21	68,604.6	69,371.2	772.7	6,472.1	6,518.7	46.73	6.05	0.05
0	2,385.5	2,388.4	3.0	1.12	0.12	57,653.8	57,910.2	262.6	6,172.2	6,175.1	3.09	1.18	0.18
3	2,419.5	2,422.6	3.1	1.12	0.12	60,680.5	60,937.1	262.7	6,206.4	6,209.5	3.16	1.20	0.20
2	2,422.6	2,425.6	3.0	1.13	0.13	60,937.1	61,195.2	264.2	6,209.6	6,212.5	3.12	1.18	0.18
3	2,425.6	2,428.6	3.0	1.11	0.11	61,195.2	61,449.5	260.4	6,212.7	6,215.5	3.00	1.15	0.15
7	2,428.6	2,431.6	3.0	1.11	0.11	61,449.5	61,705.4	261.9	6,215.7	6,218.6	3.05	1.16	0.16
1	2,190.4	2,199.4	9.0	3.47	0.47	51,579.0	51,834.3	261.4	5,980.7	5,989.7	9.14	3.50	0.50
5	2,251.5	2,260.5	9.0	3.41	0.41	53,343.0	53,601.3	264.4	6,040.5	6,049.6	9.29	3.51	0.51
1	2,260.5	2,269.7	9.2	3.54	0.54	53,601.3	53,858.7	263.4	6,049.8	6,058.7	9.06	3.44	0.44
3	2,269.7	2,279.1	9.4	3.59	0.59	53,858.7	54,116.9	264.4	6,058.8	6,067.7	9.01	3.41	0.41
6	2,116.5	2,125.0	8.5	3.34	0.34	49,007.9	49,264.5	262.7	5,901.4	5,910.1	8.85	3.37	0.37
9	2,063.6	2,072.8	9.2	3.56	0.56	47,483.8	47,737.9	260.2	5,850.2	5,859.2	9.18	3.53	0.53
2	2,907.9	2,926.4	18.5	7.08	1.08	71,916.4	72,170.4	254.5	6,681.3	6,699.3	17.94	7.05	1.05
8	2,926.4	2,944.1	17.8	6.94	0.94	72,170.9	72,427.6	262.8	6,699.5	6,717.1	17.80	6.77	0.77
8	2,944.1	2,962.8	18.7	7.28	1.28	72,427.7	72,686.0	264.4	6,717.5	6,734.8	17.50	6.62	0.62
4	2,962.8	2,981.4	18.6	7.08	1.08	72,686.0	72,944.1	264.2	6,735.1	6,753.1	18.18	6.88	0.88
8	2,981.4	3,000.0	18.6	7.25	1.25	72,944.1	73,203.7	265.7	6,753.4	6,771.3	18.01	6.78	0.78
8	2,431.6	2,434.5	2.9	1.09	0.09	61,705.4	61,959.4	260.1	6,218.7	6,221.5	2.97	1.14	0.14
1	2,470.4	2,471.6	1.2	1.93	0.93	65,034.2	65,091.3	63.2	6,256.6	6,257.9	1.45	2.29	1.29
3	2,471.6	2,473.1	1.5	2.33	1.33	65,091.3	65,149.0	63.8	6,258.0	6,259.3	1.45	2.27	1.27
6	2,473.1	2,474.5	1.4	2.44	1.44	65,149.0	65,203.1	60.3	6,259.6	6,260.9	1.45	2.41	1.41
4	2,474.5	2,475.8	1.3	2.35	1.35	65,203.1	65,257.0	60.0	6,261.0	6,262.2	1.43	2.39	1.39
0	2,153.4	2,155.6	2.2	3.57	0.57	50,031.3	50,084.3	59.1	5,938.6	5,940.9	2.43	4.12	1.12
7	2,155.6	2,158.1	2.5	4.24	1.24	50,084.3	50,139.7	61.5	5,941.2	5,942.5	1.50	2.44	-0.56
5	2,158.1	2,160.3	2.2	3.78	0.78	50,139.7	50,195.3	61.7	5,943.8	5,945.9	2.25	3.65	0.65
9	2,160.3	2,162.5	2.2	3.59	0.59	50,195.3	50,249.6	60.6	5,946.3	5,948.3	2.16	3.56	0.56
7	2,162.5	2,164.7	2.2	3.72	0.72	50,249.7	50,302.0	58.4	5,948.6	5,950.8	2.33	3.99	0.99
1	2,475.8	2,481.0	5.2	7.85	1.85	65,257.0	65,331.6	80.7	6,262.3	6,267.2	5.09	6.31	0.31
2	2,481.0	2,485.4	4.4	7.80	1.80	65,311.6	65,368.0	62.4	6,267.3	6,271.5	4.34	6.95	0.95
3	2,485.4	2,489.7	4.3	6.90	0.90	65,368.0	65,426.9	65.0	6,271.6	6,275.6	4.12	6.33	0.33
7	2,489.7	2,494.1	4.4	7.17	1.17	65,427.0	65,486.8	65.9	6,275.7	6,280.2	4.61	6.99	0.99
4	2,494.1	2,498.7	4.6	7.85	1.85	65,486.7	65,540.2	59.5	6,280.2	6,284.7	4.63	7.77	1.77

(2)

APPENDIX B

APPENDIX B

FOAM CONTROL SYSTEM OPERATION OVERVIEW

Extracted from Nordic Systems Inc. Mark II Computerized Foam Proportioning System Service Manual for U.S.A.F. P-19

Figure B-1 shows the simplified **foam control** functional diagram. The system objective is to mix foam from the **foam tank** with water from the **water tank** in the correct proportion to form a **solution**. The solution is sprayed onto the fire through the **roof turret, bumper turret, or handline**.

In the **automatic mode**, the **Foam Control System** continuously adjusts the foam flow to deliver the correct solution concentration. When the **main pump** is started, water flows through the **turret** or other discharge devices. This flow rate is measured by the **solution paddle wheel flow sensor**. The flow computer calculates the foam flow rate required to get the solution to the percentage set on the control panel. Usually this percentage is **3%**, but can be 0%, 1%, 3% or 6%. The computer opens or closes the **motorized metering valve** to adjust the mixture to the correct value.

The **foam flow rate** is measured by the **foam paddle wheel** flow sensor. From this sensor, the **foam control computer** determines the number of gallons of foam per minute flowing. The percentage of foam in the solution is determined by dividing the foam flow rate by the solution flow rate. If the actual percentage foam in the solution is too high, the computer activates the **motorized metering valve** in the "close" direction tending to reduce the foam flow. Conversely, if the actual percentage foam in the solution is too low, then the metering valve motor is activated to "open" the metering valve, increasing the foam flow rate. The duration that the motor is activated is in all cases a fraction of a second, from ten thousandths of a second to one fifth of a second. The exact duration depends on the difference between the actual and desired foam percentage as set on the foam control computer face plate.

The foam control computer monitors the flow sensors about twice a second and immediately adjusts the metering valve accordingly.

Some solution is pumped around the pump through a restriction known as an **eductor**. The eductor generates a low pressure or a suction at one of its ports. Foam is sucked from the foam tank through the eductor into the solution flow and thence back into the pump. This scheme produces foam with a uniform consistency. The process is known as the **"around the pump method"**. This process thoroughly mixes the foam and water into a homogeneous solution. Apart from the fraction that is circulated around the pump, the entire pump output is available for fire fighting by discharge through the roof turret and other discharge devices.

Since foam is drawn into the eductor by a vacuum, the **foam line** is a **low pressure** line with pressures below 10 psi above the metering valve and usually negative below. On the other hand the pump output piping, **the solution line**, is a **high pressure** line with pressures as high as 150 psi.

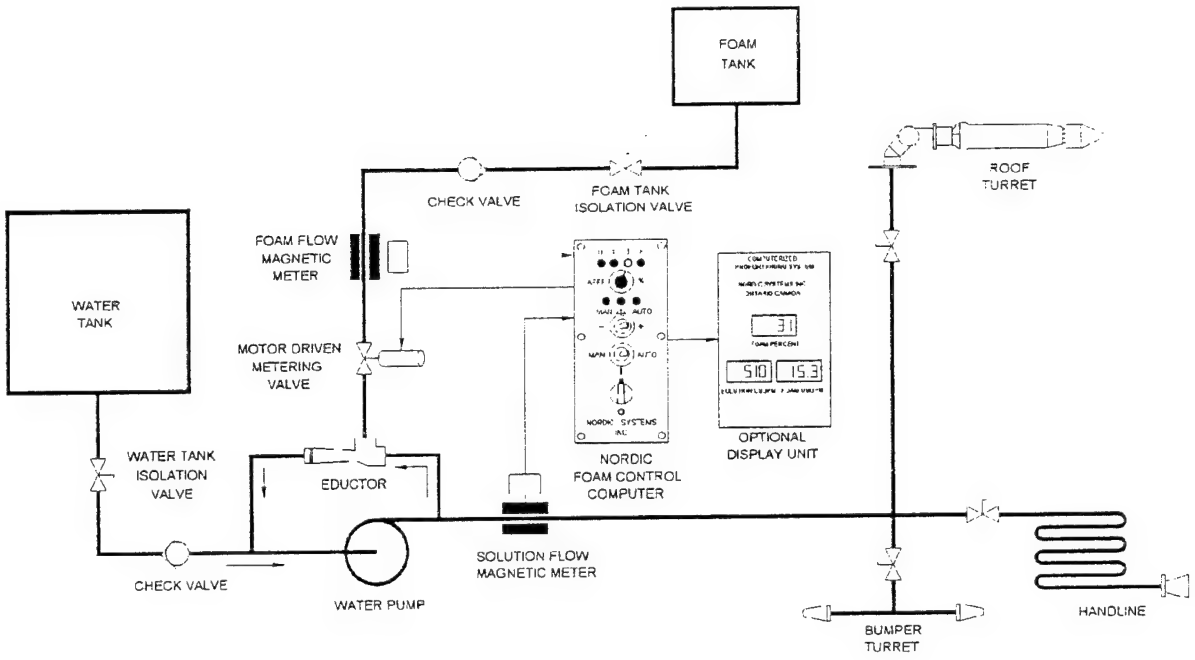


Figure B-1

Simplified foam control system including computer

COMPONENTS OF THE FOAM CONTROL SYSTEM

1 Check Valve

There are two **check valves**, one in the foam tank line and one in the water tank line. The check valves allow flow out from a tank but stop flow into a tank. Flow into a tank is an abnormal or fault condition which the check valves prohibit to avoid contamination of the tank contents. The **check valves** work automatically, and are **not controlled by the foam control system**.

2 Foam Valve

The foam valve shown in figure 1 is a pneumatically operated valve. Unless the foam valve is open, no foam can enter into the solution, only pure water will discharge from the turret. The **foam valve is not controlled in any way by the foam computer**. There are no electrical signals from the foam control computer to open or close the foam valve. The foam valve is manually activated by the operator through a three position pneumatic switch on the dashboard.

3 Foam Magnetic Flow Meter (originally a paddle wheel)

The foam magnetic flow meter (previously a paddle wheel) senses the flow of foam through the pipe from the foam tank to the eductor. The eductor which is a narrowing in the pipe around the pump, produces a low pressure or suction at the foam inlet port, thus foam is drawn into this eductor port. As the foam flows, the flow meter generates an electrical signal which is sent to the foam control computer, which calculates the actual percentage foam in the solution. Once this calculation is complete, the computer knows whether the mixture is too rich, too lean, or just right. Based upon the calculation, the computer adjusts the foam flow rate to the desired amount by opening or closing the motor driven metering valve. If the flow rate is too slow, the metering valve motor rotates the valve to increase the opening through which foam can flow. If the flow rate is too high, the metering valve is rotated to reduce the opening through which the foam can flow.

4 The Metering Valve

The **metering valve** is used to ensure that a measured volume flows through it. It consists of a ball valve driven by an electric motor, coupled through a reduction gear. This increases the motor torque or turning power and reduces its speed, both desirable properties in this application.

The motor is driven directly from the vehicles 24 Volt battery. Since it is a DC motor, reversing the polarity reverses the direction in which the motor rotates. Reversing the motor polarity is controlled by the computer to open/close the valve, thus increasing/decreasing respectively the foam percentage in the solution. Despite the gear reduction, the motor spins the metering valve so quickly that the valve can rotate from full off to full on in a couple of seconds. The computer attempts to maintain the foam percentage within one tenth of one percent of the selected value. In order to control the foam percentage in the solution to better than one tenth of a percent, the metering valve motor is pulsed as short as twenty thousandths (20/1000) of a second. For the pulse duration, the full battery voltage is applied to the motor. The average voltage varies widely depending on the duty cycle.

Needless to say, it is **crucial that the metering valve and motor drive turn freely without sticking or jamming** otherwise these very short duration control pulses will produce no valve correction and the foam control system will loose its "fine touch" or in the worst case, cease to operate at all. The **metering valve requires the most attention and service of all the components in the system**.

5 Eductor

The eductor produces suction when solution pumped **"around the pump"** is forced to flow through a restriction or narrowing in the pipe diameter. This low pressure, sometimes loosely called a **vacuum**, sucks foam concentrate from the foam tank into the eductor where it mixes with the water based solution. The rate at which foam is drawn into the eductor is controlled by the foam control computer. The foam control computer opens or closes the **metering valve** to maintain the solution foam concentration at the desired value. There are no moving parts in the eductor, it is simply a precisely shaped restriction in the pipe with a duct near the point where the restriction is greatest. The restriction is

shaped like the cross section of an aircraft wing. The restriction forces the fluid to increase in velocity (*venturi effect*) and in so doing, its pressure must fall, creating suction.

6 Main Pump

The **main pump**, when engaged by the operator, is driven by the vehicle engine. It provides the pumping action for the entire system. The pump consists primarily of an **impeller** which is spun by the vehicle motor to force solution out the discharge ports.

7 Solution Magnetic Flow Meter (originally a paddle wheel flow sensor)

This is similar to the foam flow sensor except that the flow rates are usually a least fifteen times greater. With the roof turret active, the solution flow rate is typically about 500 GPM while the foam flow rate would be 30 GPM for 6% foam solution. The solution magnetic flow meter would normally operate at pressures around 150 PSI, while the foam magnetic flow meter is experiencing a pressure from a foam column no more than six feet high, which creates a head of less than 3 PSI. This is because the foam is **gravity fed** to the foam metering valve and sucked through the metering valve by the eductor vacuum. The foam tank is not pressurized.

8 Main Turret Valve

The **main turret valve** is a pneumatically operated valve which the operator uses to turn on the main turret. When the operator activates a switch on the turret handle, compressed air is applied to the valve where it energizes a piston to fully open the main turret valve. This valve is either full open or shut off, it cannot be used to modulate the solution flow through the turret. The dispersion or shape of the turret discharge is controlled by the operator through a foot switch in the cab, near the accelerator pedal.

The **main turret valve is not controlled or monitored by the foam control computer**. It is operated independently of the computer by the operator. The foam control computer, in automatic mode, will adjust to the actual flow from zero to maximum flow rate. The computer adjusts the metering valve in response to demand, which may come from any or all the discharge nozzles.

9 Main Turret

The main turret is the **primary discharge device** for the vehicle. It is designed to mix the solution with the correct amount of air to give the solution the consistency to extinguish the fire under attack.

10 Water Tank

The water tank 1000 gallons, which will supply the turret for about two minutes operating at 500 GPM. The water is gravity fed from the water tank to the main pump. The tank is not pressurized.

11 Foam Tank

The foam tank holds the concentrated foam for mixing with water to produce the desired percentage solution. The tank holds about 130 gallons of concentrated foam. At normal operating solution percentage, 3%, there is enough foam in the tank to satisfy four

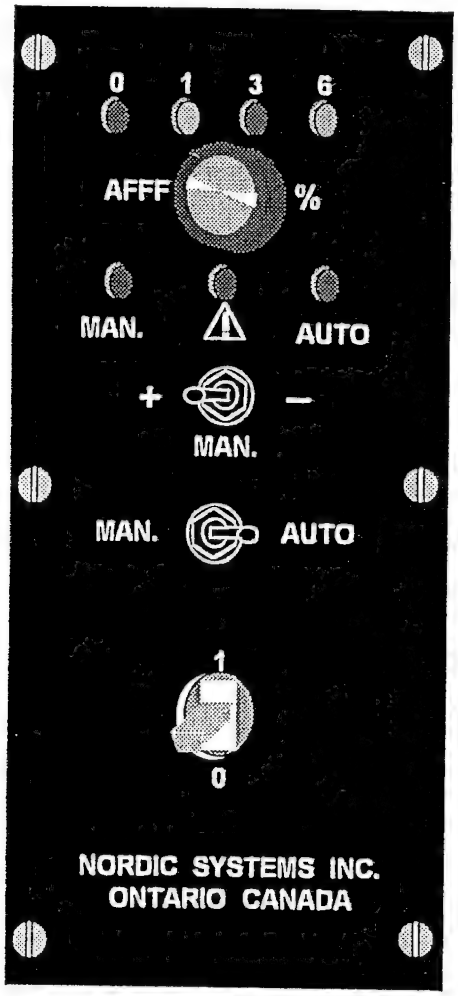
tanks of water, so that the foam tank would only have to be filled every fourth trip to refill the water tank. Like the water tank, the foam tank is not pressurized, its contents flow out under gravity.

12 Foam Control Computer

The computer, figure B-2, gets its power from the **truck battery** through a power cable. The computer receives the solution flow rate from the solution flow sensor and the foam flow rate from the foam flow sensor, with this information the foam percentage rate can be calculated. A cable connects computer power to the metering valve providing high currents to open/close the valve. An additional cable provides metering valve position to the computer. Limit switches on the metering valve indicate when it is fully open or fully closed. This limit switch information is critical to the computer which will not attempt to control the foam unless the limit switches are functioning.

The control computer can operate in **manual or automatic mode**. In **manual mode**, the operator activates the metering valve directly. This is done through a spring loaded, center off, momentary contact switch. If the switch is pushed in the **"+"** direction, the valve rotates in the **open** direction, while a push in the **"-"** direction rotates the valve in the **close** direction. The longer the switch is held, the greater the valve response. The valve will **remain in the position** it is in when the switch is released (***returns to the center position***). When the limit switches indicate that the valve is fully open/closed, no further motion in the respective direction is permitted. Circuits in the controller **chop the current** applied to the metering valve to slow down the speed of operation thereby making it feasible for the operator to accurately control the valve.

In **automatic mode**, the foam control computer automatically monitors the solution flow. It computes the required foam flow based on the percentage foam setting on the console and the actual solution flow rate. If the actual foam percentage in the solution is too low, it opens the metering valve in proportion to the error. The metering valve motor rotates the valve in a direction to increase the opening through which foam can flow. If the flow rate is too high, the metering valve is rotated in the direction to reduce the opening through which the foam can flow. This monitoring and **adjustment** is carried out about **two times per second**.



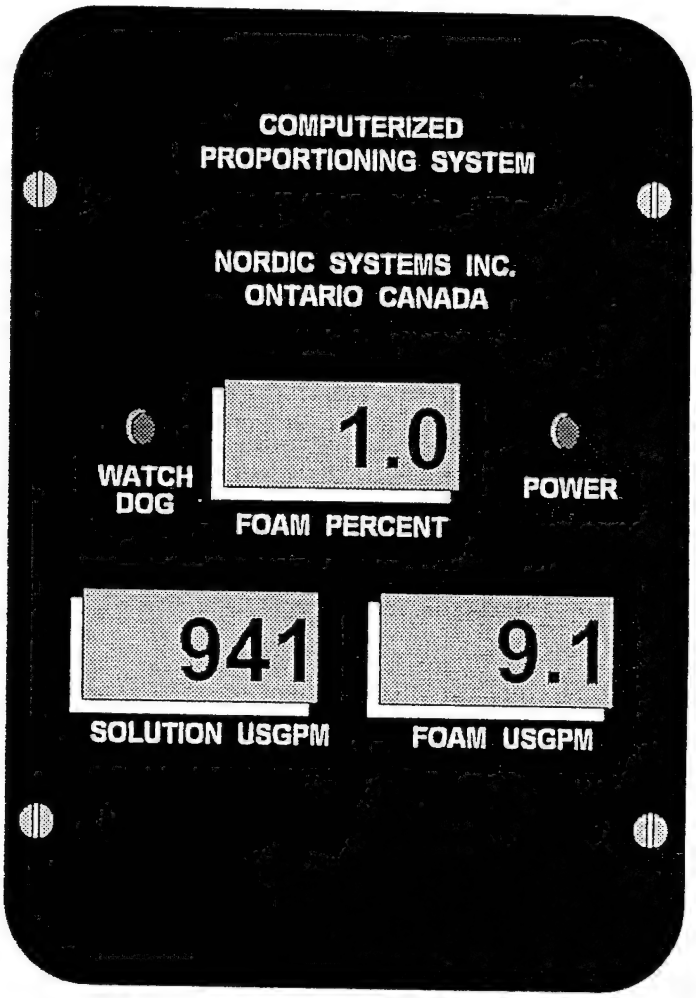


Figure B-2

NORDIC Mark IIA Computerized Foam Proportioning System
Dashboard Control and Display Panel

APPENDIX C

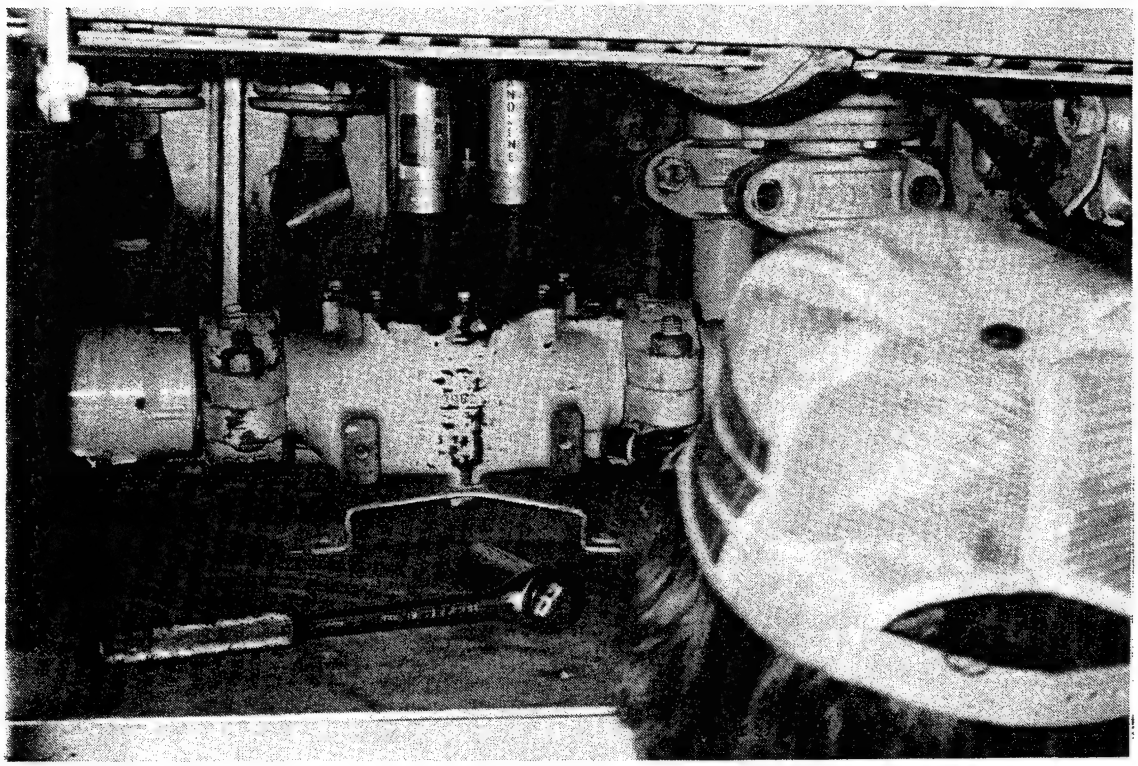


Photo 1 Original Around-the-pump metering System

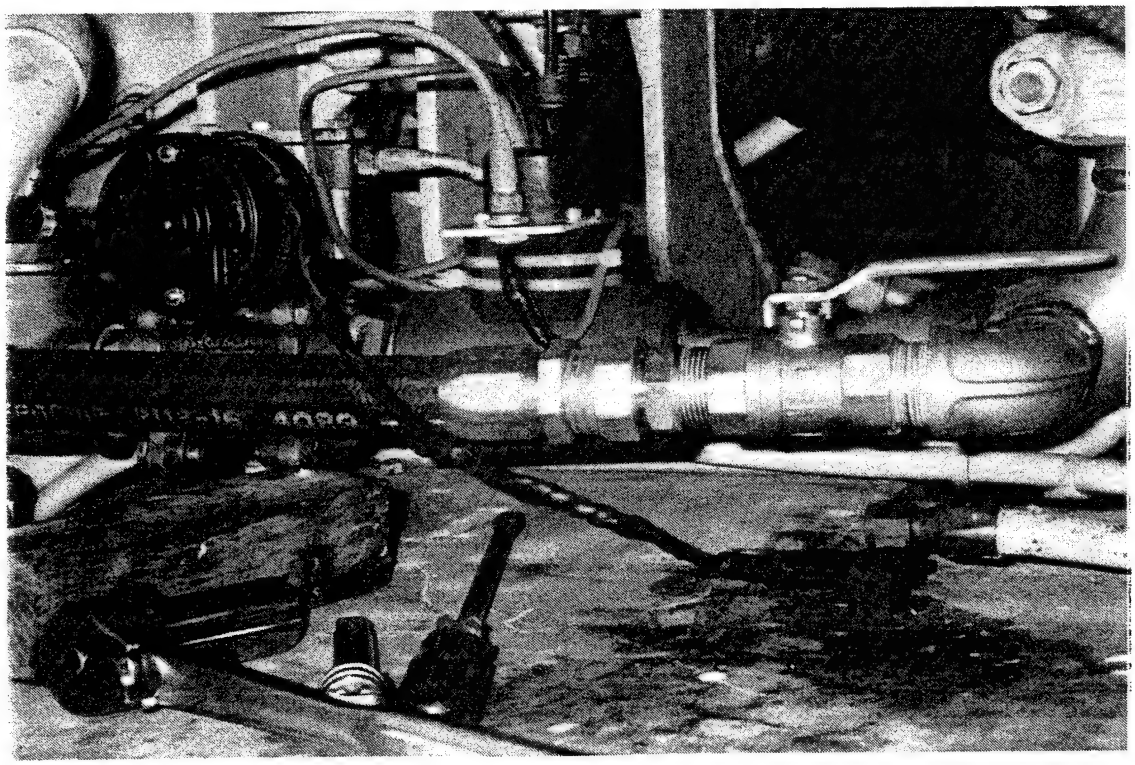


Photo 2 NORDIC Mark IIA Computerized Foam Proportioning System Installed

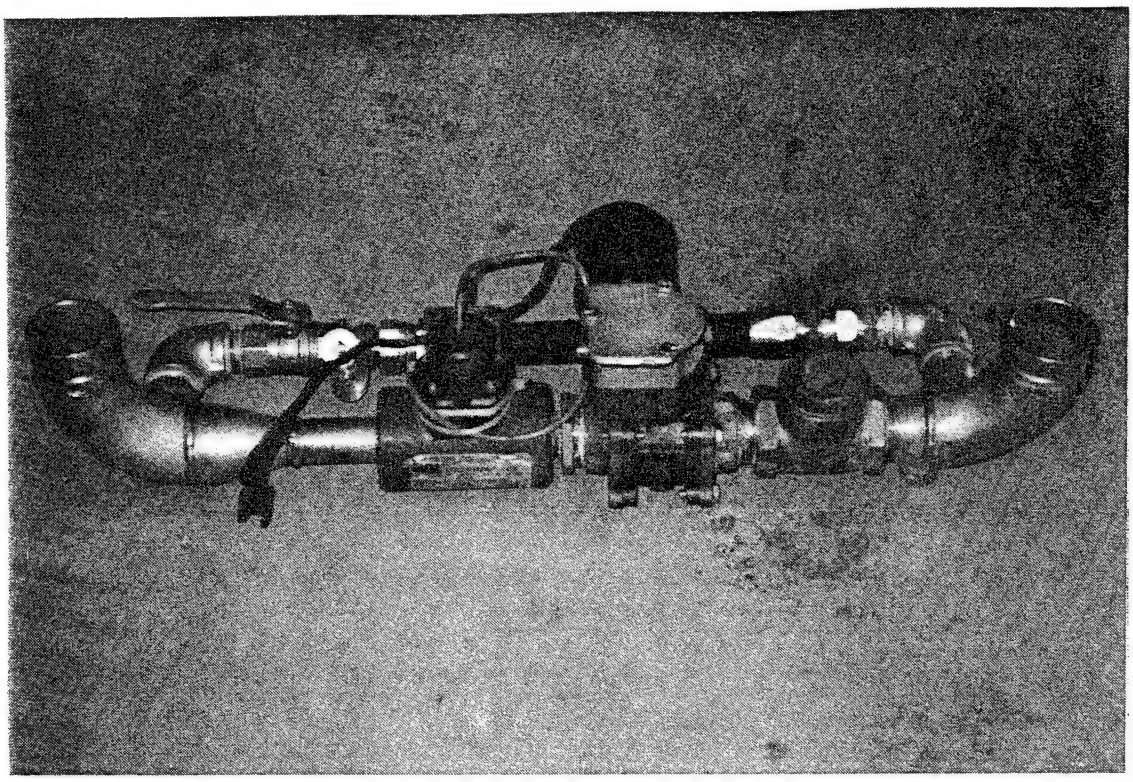


Photo 3 NORDIC Mark IIA Computerized Foam Proportioning System Valves and Plumbing

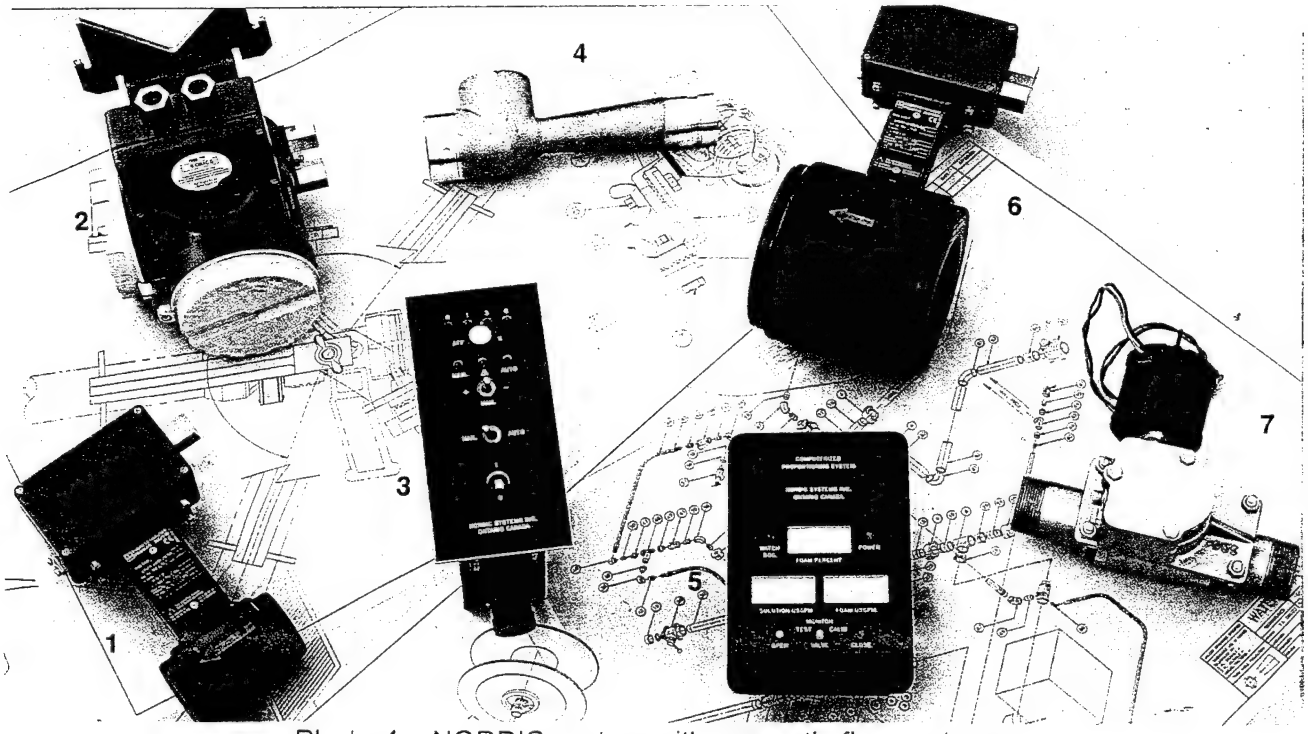


Photo 4 NORDIC system with magnetic flow meters

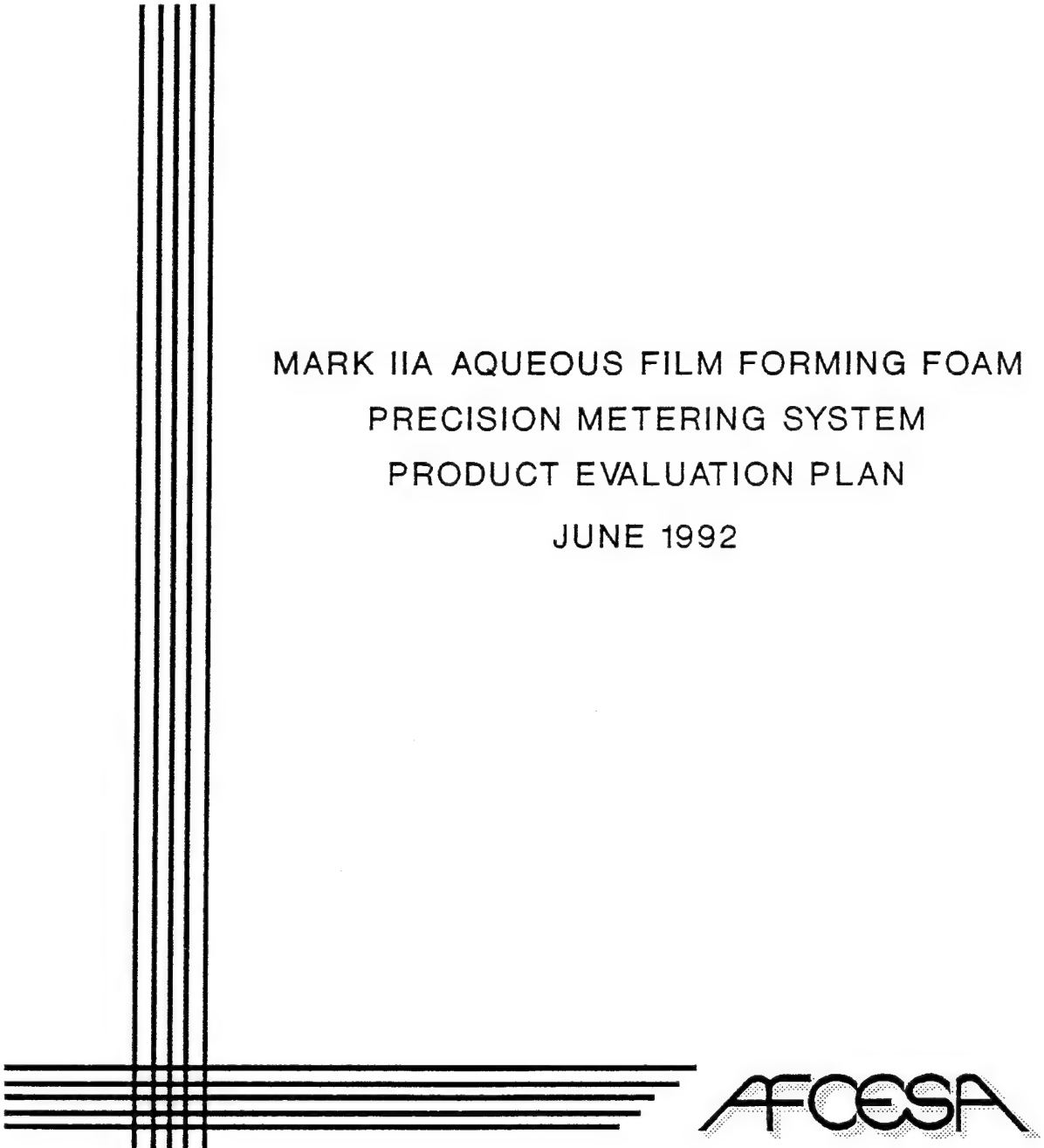
1. Foam concentrate magnetic flow meter sensor 2. Magnetic flow meter transmitter 3. Computer 4. Eductor 5. Optional digital display 6. Solution magnetic flow sensor 7. metering valve

APPENDIX D

APPENDIX D

MARK IIA AQUEOUS FILM FORMING FOAM PRECISION METERING SYSTEM PRODUCT EVALUATION PLAN

JUNE 1992



AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TYNDALL AIR FORCE BASE, FLORIDA 32403

MARK IIA AQUEOUS FILM FORMING FOAM
PRECISION METERING SYSTEM
PRODUCT EVALUATION PLAN
JUNE 1992

Revisions to this Evaluation Plan involving changes in scope or resources will be approved by the Chief of Fire Protection, HQ AFCESA.

PREPARED BY:

Wade H. Grimm

WADE H. GRIMM, GS-11
Project Manager

REVIEWED BY:

Hugh A. Pike

HUGH A. PIKE, GS-12
Project Engineer

Richard N. Vickers

RICHARD N. VICKERS, GS-12
Evaluation Manager

APPROVED BY:

Paul K. Laird 24 June 92

PAUL K. LAIRD, GM-14
Chief, Firefighting and Facilities Branch

CONTRACT SPONSOR: HQ AFCESA/RA

PROJECT SPONSOR: HQ AFCESA/RAAE, Mr Laird

TELEPHONE NUMBER: DSN 523-6290

PROJECT ADVOCATE: HQ AFCESA/DF, CMSgt Reyff

TELEPHONE NUMBER: DSN 523-6156

ABSTRACT

This plan specifies procedures to evaluate a commercially developed aqueous film forming foam (AFFF) metering system installed in an A/S32P-19 firefighting vehicle. The system can be controlled by the vehicle operator without dismounting or relinquishing control of the vehicle. Headquarters Air Force Civil Engineering Support Agency, Firefighting and Facilities Branch, has overall responsibility for program management. The Responsible Test Organization, HQ AFCESA/RACF, will conduct the evaluation at Tyndall AFB, Florida, at Fire Research Facility #1. One off-the-shelf AFFF metering system manufactured by Nordic Systems Inc. will be evaluated. The primary focuses of this evaluation are to examine the metering accuracy, system performance, operational effectiveness, and suitability of the AFFF system. The results of the evaluation will be used to support a decision to modify existing firefighting apparatus.

TABLE OF CONTENTS

ABBREVIATIONS

AFFF	AQUEOUS FILM FORMING FOAM
AFR	AIR FORCE REGULATION
Ao	OPERATIONAL AVAILABILITY
CFR	CRASH FIRE RESCUE
DOD	DEPARTMENT OF DEFENSE
DSN	DEFENSE SWITCHING NETWORK
gal	GALLON
gpm	GALLONS PER MINUTE
HQ AFCESA AGENCY	HEADQUARTERS AIR FORCE CIVIL ENGINEERING SUPPORT
IAW	IN ACCORDANCE WITH
LTI	LIMITED TECHNICAL INSPECTION
MC	MISSION CAPABLE
MDT	MEAN DOWN TIME
MOE	MEASURE OF EFFECTIVENESS
MTBM	MEAN TIME BETWEEN MAINTENANCE
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
NMC	NOT MISSION CAPABLE
P-19	A/S32P-19 CRASH FIRE RESCUE VEHICLE
RM&A	RELIABILITY, MAINTAINABILITY, AND AVAILABILITY
RTO	RESPONSIBLE TEST ORGANIZATION

SECTION I
INTRODUCTION

1.1 Purpose. Headquarters Air Force Civil Engineering Support Agency (HQ AFCESA), Firefighting and Facilities Branch (RAAE), will manage a product evaluation to verify metering accuracy, operational effectiveness, and suitability of the Nordic Systems Inc. Mark IIA Computerized Foam Proportioning System (hereafter called Mark IIA). The evaluation will be conducted by the Responsible Test Organization (RTO), HQ AFCESA/RACF, from 13 July through 9 November 1992, at Fire Research Facility #1, Tyndall AFB, FL. HQ AFCESA/RAAE will use the data collected to compare the aqueous film forming foam (AFFF) metering accuracy, foam discharge pattern, and hydrocarbon fire extinguishing capability of the Mark IIA with two other systems: the orifice plate system currently employed on the P-19 and the Hypro Corporation's metering system previously evaluated by RACF. The results of the evaluation will support a decision to retrofit Air Force AFFF firefighting apparatus. If applicable, the Department of Defense (DOD) could use the results of the evaluation for other firefighting vehicles.

1.2 System Description. The Mark IIA AFFF metering system is a computerized foam proportioning system. Nordic Systems Inc. personnel will install and calibrate the Mark IIA system on RACF's P-19 firefighting vehicle used in the evaluation and provide operator and maintenance training to evaluation participants. The system is government property and will be available for other test purposes if required. During the Mark IIA installation, Nordic Systems Inc. personnel will require some assistance from RACF personnel to install sight gauges on the water and AFFF tanks, and provide information on the P-19 water system. The Mark IIA system consists of: a computer, foam flow meter, solutions flow meter, foam control valve, a self-contained digital read-out unit, and associated wiring and electrical connectors. The Mark IIA computer program has been modified to meet current USAF objectives to provide foam in concentrates of 1.0%, 3.0%, and 6.0% at flow rates between 60 and 500 gallons per minute (GPM). The AFFF dispensing ratio of the Mark IIA system is switch selectable over a range of 0-6.0% AFFF by the operator from the cab of the vehicle. After the AFFF reservoir is serviced with foam concentration, the vehicle operator can adjust the Mark IIA the match the AFFF concentration in the reservoir.

1.3 Background. The DOD currently uses AFFF concentrates formulated and mixed with water in ratios of 3 and 6 percent, using an around-the-pump proportioning system with fixed orifices. Common fire protection community terminology refers to an AFFF concentrate designed to be mixed with water at a ratio of 3% AFFF to 97% water as "3% AFFF". A "6% AFFF" concentrate contains approximately one-half of the surfactant and other active ingredients as 3% AFFF concentrate per unit volume and, consequently, is referred to as "less concentrated". When mixed with water at their designed ratios, both types AFFF/water mixture are essentially the same. By using 1.0% AFFF concentrate (as compared to 3% and 6%), agent conservation and extended firefighting capability should be realized. Six percent foam concentrate will be evaluated to provide system performance data in case situations arise again where the Air Force "borrows" 6.0% foam from the Navy during Desert Storm. This product evaluation will be accomplished as part of a continuing effort to identify an AFFF system capable of metering foam accurately at 1% concentration.

1.4 Objectives. The primary objectives of this evaluation are to verify the AFFF metering accuracy and consistency of the Mark IIA system in the P-19 firefighting vehicle. The secondary objectives are to determine the effects of the Mark IIA system on the foam discharge pattern and the ability to produce quality foam. This evaluation will assess the Mark IIA system performance, operational effectiveness, and suitability for use with the P-19. The specific objectives are:

1.4.1 Objective E-1. Assess the Mark IIA system/P-19 integration and vehicle modification procedures.

1.4.2 Objective E-2. Assess the operational performance of the Mark IIA system installed on the P-19.

1.4.3 Objective S-1. Assess the compatibility of the Mark IIA system installed on the P-19 with firefighting operations.

1.4.4 Objective S-2. Assess the adequacy of technical data provided with the Mark IIA system.

1.4.5 Objective S-3. Assess the Mark IIA system Reliability, Maintainability, and Availability (RM&A).

1.5 Evaluation Concept and Scope.

1.5.1 Prior to modifying the P-19 vehicle with the Mark IIA system, the RTO will demonstrate the AFFF metering accuracy, foam discharge pattern, and foam quality of the existing orifice plate system. The results will be documented, and a performance baseline created for comparison with the Mark IIA system. After the orifice plate system has been baselined, the Mark IIA system will be installed on the same P-19 vehicle and the same AFFF metering accuracy, foam discharge pattern, and foam quality data will be collected on the Mark IIA.

1.5.2 Evaluation Conditions. The evaluation participants from RACF/ARA will be task qualified firefighting and maintenance personnel. Fire suppression capability demonstrations will consist of a 300 gallon hydrocarbon fire set in the RACF Fire Research Facility #1 pit. At the conclusion of each foam percentage evaluation, the AFFF metering accuracies and foam discharge patterns will be measured using the sight gauges and spray measurements to evaluate the repeatability of the Mark IIA system to consistently provide 1.0%, 3.0%, and 6.0% AFFF.

1.5.3 Procedures. AFFF metering accuracy evaluation data requirements are outlined in the data forms 6, 7, and 8. Foam discharge pattern evaluation procedures and data requirements are outlined in NFPA Standard 412. General firefighting practices and procedures as outlined in Air Force Regulation (AFR) 92-1, Fire Protection Program, will be followed. The safety and protection of personnel and equipment will take priority over accomplishing any evaluation task or objective.

1.5.4 Authority for the Mark IIA system product evaluation is in PMD 8028(9), dated 10 May 1991. This evaluation will be conducted as directed in AFR 80-14 and AFR 55-43, and a final report will be released for publication no later than 45 calendar days after the final evaluation data are collected processed.

1.5.5 Mark IIA system reliability data will be reported as mature system point data since the system is commercially available (off-the-shelf).

SECTION II
OBJECTIVES AND EVALUATION METHODOLOGY

2.1 General Method of Accomplishment. The capabilities of the Mark IIA system installed on a P-19 fire truck will be assessed for AFFF metering accuracy, foam discharge pattern, and fire suppression of controlled aircraft type hydrocarbon fires set in RACF's Fire Research Facility #1. The data on system performance, operational effectiveness and suitability will be recorded and reported as point data due to the relatively short evaluation period. Incompatibilities between the system and operational requirements will be documented on data forms provided and will include the procedures followed leading to the noted incompatibility, suggested corrective procedures, suggested hardware changes, and actions required to continue with operations.

2.2 Objective E-1. Assess the Mark IIA system/P-19 integration and vehicle modification procedures.

2.2.1 Measure of Effectiveness (MOE) and Evaluation Criterion. The MOE is noninterference. The criterion is no mutual interference between or among the P-19 and the Mark IIA system.

2.2.2 Method. Nordic Systems technicians will be assisted by RACF personnel during the installation and calibration of the Mark IIA system in the P-19 evaluation vehicle. They will perform a limited technical inspection (LTI) and functionally operate the Mark IIA modification prior to beginning the evaluation. RACF/ARA/BDM personnel will compare the installed hardware and components to the technical data package provided by Nordic Systems Inc. to verify completeness. The orifice plate system removed from the P-19 will be inventoried, inspected for completeness and apparent serviceability, and stored by RACF.

2.2.3 Data Requirements.

Element	Source
Inputs from Evaluation Manager	Data Forms 1 and 3
Inputs from Evaluation Participants	

2.2.4 Data Collection and Processing. Evaluation participants will collect, compile, and categorize data during the evaluation. The Evaluation Manager will have primary responsibility for ensuring the accuracy and validity of the data collected. Data forms will be completed as required. The evaluation data will be the basis of the evaluation report.

2.3 Objective E-2. Assess the operational performance of the Mark IIA system installed on the P-19.

2.3.1 MOE and Evaluation Criteria. The MOE is Mark IIA system performance. The criteria are that the Mark IIA system consistently repeat metering accuracy, foam discharge patterns, and fire suppression capabilities.

2.3.2 Method. The P-19 vehicle water and AFFF tanks will be calibrated following the Firefighting Vehicle Fluid Calibration Procedures in data form 5. The P-19 and Mark IIA systems will be serviced and prepared for use in accordance with applicable technical manuals. After preparation for use, the P-19 and Mark IIA systems will be operated to dispense AFFF ten times from each turret/nozzle (roof, bumper, and handline) for 60 seconds with 1%, 3%, and 6% AFFF. After each

60 second dispensing operation, the water and AFFF tank quantities will be recorded using fluid sight gauges on the vehicle to determine the amounts used. This will be accomplished to compute the Mark IIA system metering accuracy and to determine repeatability with the various AFFF concentrations. The handline is included to determine the Mark IIA's ability to accurately meter AFFF at the lower flow rate of 60 GPM. To determine AFFF dispersal pattern consistency, the procedures in NFPA Standard 412, paragraph 4-1, Turret Ground Pattern Test, will be followed. The Mark IIA system will then be employed IAW standard firefighting procedures to extinguish 300 gallon pit fires to demonstrate fire suppression capabilities with 1%, 3%, and 6% AFFF concentrations. During dispensing operations, special attention will be given to the Mark IIA system performance. Incompatibilities between the Mark IIA system and the P-19 fire truck or other CFR equipment will be recorded in detail. Likewise, enhanced capabilities due to the Mark IIA system performance or its interface with other CFR equipment will be recorded in detail.
During the live fire events, the Evaluation Manger will insure compliance with the safety procedures identified in Section IV.

2.3.3 Data Requirements.

Element	Source
Inputs from Project Manager	Data Forms 1 through 8
Inputs from Evaluation Participants	

2.3.4 Data Collecting and Processing. Evaluation participants will collect, compile, and categorize data during the evaluation. The Evaluation Manager will have primary responsibility for ensuring the accuracy and validity of the data collected. Data forms will be completed as required. The evaluation data will be the basis of the evaluation report.

2.4 Objective S-1. Assess the compatibility of the Mark IIA system with the P-19 firefighting vehicle.

2.4.1 MOE and Evaluation Criterion. The MOE is compatibility among and between all components of the Mark IIA system and the
P-19 in the operational environment. The criterion is that the performance of the Mark IIA system neither prevent nor hinder successful performance of any evaluation event.

2.4.2 Method. The Mark IIA system will be employed as described in paragraph 2.3.2 and maintained IAW the operational concept and the manufacturer's technical data. The evaluation participants will be briefed to be alert for any actual or foreseeable compatibility problems between and among the components. The evaluation participants will notify the Evaluation Manager of any observed or experienced compatibility problems. The Evaluation Manager will record their comments in the Evaluation Manager's Log.

2.4.3 Data Requirements.

Element	Source
Inputs from Project Manager	Data Forms 1,2,3 and 4
Inputs from Participants	

2.4.4 Data Collection and Processing. Same as Paragraph 2.2.4.

2.5 Objective S-2. Assess the adequacy of the vendor provided technical manuals for the Mark IIA system.

2.5.1 MOE and Evaluation Criteria. The MOE is the adequacy of the technical manuals as judged by evaluation participants. The criteria are that the documents be written so a task-qualified technician can readily understand and follow the procedures and, by following the procedures, achieve the intended outcome.

2.5.2 Method. During this evaluation, participants will use the vendor provided technical manuals. After each evaluation event, the participants will indicate, on data forms and maintenance logs, any difficulties that prevented or hindered successful task performance. The Evaluation Manager will record reported problems, pertinent observations, and comments in the Evaluation Manager's Log.

2.5.3 Data Requirements.

Element	Source
Inputs from Project Manager	Data Forms 1,2,3 and 4
Inputs from Participants	System Operator's Manual

2.5.4 Data Collection and Processing. At the conclusion of the evaluation, the team will compile the collected data. Technical manual deficiencies will be reviewed and verified prior to inclusion in the evaluation report. The Evaluation Manager will be responsible for ensuring reported technical manual deficiencies are clearly and completely explained.

2.6 Objective S-3. Assess the Mark IIA system Reliability, Maintainability, and Availability (RM&A).

2.6.1 MOE and Evaluation Criterion. The MOE is system RM&A. There is no criterion established for this system.

2.6.2 Method. The system will be employed as described in this section. The Evaluation Manager and participants will record system failure and repair data. These data will be used to calculate system point RM&A rates for the evaluation period.

2.6.3 Data Requirements. Same as paragraph 2.5.3.

2.6.4 Data Collection and Processing. The evaluation participants will collect, compile, and categorize data during the evaluation. The Evaluation Manager will have primary responsibility for ensuring the accuracy and validity of the data collected. Failures will be recorded and reported in chronological order on data forms. The failure data will be used to calculate the Mean Time Between Maintenance (MTBM), Mean Down Time (MDT), and Operational Availability (Ao) as follows:

$$\text{MTBM} = \frac{\text{TOTAL OPERATING TIME}}{\text{TOTAL NUMBER OF MAINTENANCE EVENTS}}$$

$$MDT = \frac{\text{TOTAL MAINTENANCE REPAIR TIME}}{\text{TOTAL NUMBER OF REPAIR ACTIONS}}$$

$$Ao = \frac{\text{POSSESSED TIME - DOWN TIME}}{\text{POSSESSED TIME}} \times 100$$

Maintenance Events for MTBM calculations are defined as any maintenance action required to correct a Mark IIA system or component malfunction which renders it not mission capable. P-19 fire truck failures will be recorded but not charged to the Mark IIA system RM&A rates. The total operating hours shall be the sum of the hours taken from the Operational Status Log and will include the total time the system was in use. The time the system is not serviceable due to a failure will not be included as operating hours. The MDT will not include time lost due to the non-availability of replacement components. The system developed for this evaluation was not provisioned with spare/replacement components; therefore, the time required to arrange for the replacements from the vendor will not be charged against the system. Repair time will count only the time required to troubleshoot and physically repair the actual failure. The Ao will be expressed as the percentage of time the system is available for use with respect to the total time required for use.

SECTION III
MANAGEMENT AND RESOURCES

3.1 Management Relationships.

3.1.1 HQ AFCESA/RAAE will exercise overall program direction and provide funding for the Nordic Systems Inc. Mark IIA AFFF computerized metering system evaluation. HQ AFCESA/RACF, the Responsible Test Organization (RTO), will conduct the evaluation and provide the data collected to RAAE for analysis and reporting.

3.1.2 HQ AFCESA/RACF will organize evaluation events, collect and correlate data, and provide security, storage, and personnel support for the evaluation. Upon completion of the evaluation, RACF with RAAE will publish an evaluation report within 45 days of receipt of the compiled evaluation data.

3.2 Key Personnel. Table 1 lists personnel who are responsible for evaluation planning, implementing, and reporting.

TABLE 1. KEY PERSONNEL

Title	Name/Grade	Organization	Phone (DSN)
Project Sponsor	Mr Laird	HQ AFCESA/RAAE	523-6290
Project Advocate	CMSgt Reyff	HQ AFCESA/DF	523-6156
Project Manager	Mr Grimm	HQ AFCESA/RAAE	523-6303
Evaluation Manager	Mr Vickers	HQ AFCESA/RACF	523-3734
Project Engineer	Mr Pike	HQ AFCESA/DFE	523-3742
Technical Advisor	Mr Wilson	ARA	523-3169
Technical Advisor	Mr Dees	ARA	523-3169

3.3 Resources. HQ AFCESA/RACF will provide facilities, consumables, equipment, and personnel to support this evaluation.

3.3.1 Evaluation Support. Table 2 lists evaluation support requirements.

TABLE 2. EVALUATION REQUIREMENTS

EQUIPMENT ITEMS QUANTITY	
MODIFIED A/S32P-19/Mark IIA	1 (full time)
PORTABLE VIDEO CAMERA	1 (during events)
35 MILLIMETER STILL CAMERA	1 (during events)
STOPWATCH	2 (during events)
100-FOOT MEASURING TAPE	1 (during events)
CONSUMABLE ITEMS **QUANTITY**	
FUEL (SUITABLE FOR LIVE FIRE EVENTS)	800 gallons
1/2-INCH VIDEO TAPE	5 each
35 MILLIMETER FILM (COLOR SLIDES and PRINTS)	5 rolls
WATER	18,000 gallons
AFFF	
1%	250 gallons
3%	600 gallons
6%	1100 gallons
FACILITIES	
MAINTENANCE BAY	1 (as required)
STORAGE BAY	1 (as required)
FIRE PIT	1 (as required)

3.3.2 The Evaluation Manager is authorized to contact Nordic Systems Inc. directly, as necessary, to aid in accomplishing this evaluation; however, he may not offer to purchase or obligate the Air Force in any way. This must be clearly stated in all communications with commercial vendors. As soon as it is practical, the Evaluation Manager will notify HQ AFCESA/DF and RAAE of any reportable evaluation related personnel injury or catastrophic system failure, caused by or relating to the use of the P-19/Mark IIA system. At the completion of the evaluation, the Evaluation Manager will collect and compile the data required to publish an evaluation report. HQ AFCESA/RAAE will prepare the evaluation report.

3.4 Release of Information.

3.4.1 HQ AFCESA/PA, DSN 523-6476, is responsible for information coverage of this evaluation. Clearance of information will be in accordance with AFR 190-1, Public Affairs Policies and Procedures, Chapters 6 and 9. News releases, if any, will spotlight the evaluation purpose, equipment, methods, and participating personnel. No value judgement will be made.

3.4.2 The Evaluation Manager is responsible for informing HQ AFCESA/DF and RAAE of any incident or mishap. The releasing authority for information on any incident or mishap is HQ AFCESA/PA, through the safety office of the evaluation location or the base public affairs officer, after coordination with the HQ AFCESA/CC. Releases will be made in accordance with AFR 190-1.

SECTION IV
SAFETY PLAN

4.1 Purpose. General firefighting practices and procedures are outlined in Air Force Regulation (AFR) 91-1, Fire Protection Program, will be followed throughout the evaluation. The safety and protection of personnel and equipment takes priority over accomplishing any evaluation objective. Every effort will be made to prevent deviating from preplanned actions, and standard operating practices and procedures. Deviations may only be authorized by the evaluation manager with the concurrence of the AFCESA safety officer. This Safety Plan establishes the safety areas for live fires using partial percentage AFFF. Live fires will be conducted at the AFCESA Fire Research Facility #1. This document contains detailed safety rules which govern the conduct of this evaluation series. The Evaluation Manager will act as Supervisor of Fire Test (SOFT) and will ensure adherence of all safety policies. Before conducting any live fires at the Fire Research Facility, the Base Fire Department Communications Center will be notified. The following documents are applicable to this test:

AFOSH 127-40 & 42, Emergency Eye Wash
AFOSH 127-11 & 50, First Aid Kits
AFOSH 127-31, Personal Protective Clothing and Equipment
AFR 92-1, Paragraph 4-14, Safety Equipment for Fire Fighters
AFR 127-4, Accident Reporting

4.2 Overall Safety Responsibility. HQ AFCESA/RACF, as Evaluation Manager, is responsible for enforcing the overall safety program for the evaluation. The Evaluation Manager or his designated representative will act as the Safety Officer during all fire events at the test site.

4.3 General Safety.

4.3.1 Safety Briefing. The Evaluation Manager will inform all test personnel on known safety hazards associated with this test and test site. Supervisors will, in turn, inform their personnel on these hazards.

4.3.2. Visitors. Visitors will be permitted at the test site only with the approval of the Evaluation Manager. Visitors will be instructed on applicable safety regulations.

4.3.3. Individual Safety Responsibility. Careful attention to potential hazards associated with fire testing must be stressed at all levels of responsibility. The purpose of the safety rules outlined herein is to present the most important elements in experimenting with controlled fires. These rules do not cover all the possible hazards which may occur at the site. As new problems arise, new safety measures must be established. This Safety Plan must be strictly adhered to by all personnel and enforced by all supervisors.

4.3.4 First Aid. A first-aid kit will be maintained at the site and all personnel will be informed on its location.

4.4 Accident Reporting (Emergency).

4.4.1 Scope. The purpose of this procedure is to ensure expedient handling and care of personnel injured in an accident or disaster. All post-emergency reporting and investigation of an accident will be performed in accordance with applicable Air Force regulations.

4.4.2 Responsibility. Each person involved in this program must be familiar with the emergency reporting procedures established by this plan and immediately implement these procedures in the event of an accident. The Evaluation Manager will ensure that all supervisors and subordinates are familiar with this procedure.

4.4.3 Emergency Reporting Procedures. In the event of an accident at the test site, the following procedures will be followed:

a. The Evaluation Manager will direct appropriate first aid. Caution will be exercised to prevent aggravation of an accident-related injury.

b. Tyndall Air Force Base Hospital Ambulance Service will be notified by calling extension 911. The nature of the accident, including apparent condition of injured personnel and the location of the test site, will be reported to the medical personnel. The Evaluation Manager or his designated representative will decide whether to transfer the injured directly to a hospital or to request emergency ambulance support.

c. The Evaluation Manager or his designated representative will determine the seriousness of the accident. If the accident is not serious enough to require emergency hospitalization or ambulance service, the injured person will be taken to a doctor or hospital by normal means of transportation.

d. All accidents requiring emergency treatment or first aid must be reported to the AFCESA Safety Officer.

4.5 Fire Prevention, Reporting, and Emergency Procedures.

4.5.1 Responsibility. The Evaluation Manager will be responsible for the implementation of the procedures established by this plan. All on-site personnel must be completely familiar with these procedures to ensure proper response to an emergency.

4.5.2 Fire Prevention Procedures. The procedures listed in Check List #1 are to be followed in an effort to reduce chances of an uncontrolled fire.

4.6 Test Site Location. All fire evaluations will be conducted at the 100 foot AFCESA Fire Research Facility #1, located on Farm Dale Road. These tests will be conducted in accordance with AFCESA Office Instruction dated 7 April 1988, entitled "Live Fire Demonstration/Tests". The following checklist will be used prior to conducting live fire evaluations.

CHECK LIST #1
TO BE USED BEFORE CONDUCTING LIVE FIRES AT
FIRE RESEARCH FACILITIES NO. 1

DATE:_____ TIME:_____

VERIFIED PROCEDURES

____ Inform all personnel on proper safety precautions.
____ All personnel at the test site are needed to support the test or an approved visitor?
____ Inform all personnel on accident and fire reporting procedures.
____ Radio or telephone communications available?
____ Inform all personnel of the telephone numbers for the ambulance and fire department.
____ Ensure a first aid kit is available.
____ Ensure an emergency eye wash station is available.
____ Ensure all fuel valves are closed and there are no fuel leaks prior to fuel ignition.
____ Secure area prior to igniting fire.

4.7 Notification. Before conducting a fire test, notify the Fire Department Communications Center at Extension 3-2884. The Fire Department Communications Center will need an estimate of the duration of the live fire tests. The Communications Center will be requested to notify the following:

a. Command Post - 3-2155
b. Air Traffic Control Tower - 3-4553
c. Base Hospital - 3-7514
d. Security Police - 3-2028
e. Division of Forestry - 3-2641
f. Base Weather - 3-2856

ANNEX 1

DATA FORMS

AN ABBREVIATED SET OF DATA FORMS ARE INCLUDED ON THE FOLLOWING PAGES

DATA FORM #1
EVALUATION MANAGER'S LOG

DATE	EVENT & COMMENT

DATA FORM # 2
FAILURE LOG

DATE	FAILURE CLASSIFICATION / CAUSE / CORRECTIVE ACTION

DATA FORM # 3
EVALUATION EVENT LOG

DATE	EVENT	COMMENT

ADDITIONAL COMMENTS:

DATA FORM # 4
OPERATIONAL STATUS LOG

DATE	TIME	STATUS	COMMENT

STATUS CODES: MC - MISSION CAPABLE, THE SYSTEM IS READY FOR USE.

NMC - NOT MISSION CAPABLE, THE SYSTEM CANNOT BE USED DUE TO A HARD FAILURE.

NMR - NOT MISSION READY, THE SYSTEM IS OUT OF SERVICE FOR A SCHEDULED INSPECTION OR SERVICING (NOT A SYSTEM FAILURE). "NMR TIME" WILL BE COUNTED AS "MC TIME" FOR PURPOSES OF CALCULATING SYSTEM RM&A DATA UNLESS A FAILURE IS DISCOVERED DURING THE MAINTENANCE ACTION.

DATA FORM # 5
FIRE FIGHTING VEHICLE FLUID CALIBRATION PROCEDURES

A. Water Tank Calibration.
1. Ensure that water tank is empty.
2. Ensure that the vehicle is parked on a level surface throughout tank calibration procedures.
3. Using a liquid flow meter, fill tank in 50 gallon increments, to its 1,000 gallon capacity, and calibrate a tank level indicator (dip stick) at 50 gallon increments.

B. AFFF Tank Calibration.
1. Ensure that AFFF tank is empty.
2. Ensure that the vehicle is parked on a level surface throughout tank calibration procedures.
3. Using a liquid flow meter, fill AFFF tank in 5 gallon increments, to its 130 gallon capacity, and calibrate a tank level indicator (dip stick) at 5 gallon increments.

DATA SHEET
WATER TANK

Date:_____ Vehicle Registration Number:_____
Test Conductors:_____

Fill Point	Water Gallons	Water Depth
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

DATA SHEET
AFFF TANK

Date:_____ Vehicle Registration Number:____
Evaluator:_____

Fill Point	AFFF Gallons	AFFF Depth
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

ALL METERING SHEETS IN ORIGINAL TEST PLAN INCLUDED 10 RUNS UNDER EACH CATEGORY

DATA FORM # 6
1% AFFF METERING TEST MATRIX
AND
DATA COLLECTION SHEET

TEST NO.	TURRET	AFFF TANK	DISPENSING TIME (sec)	WATER TANK START	WATER TANK END	AFFF TANK START	AFFF TANK END	WATER USED	AFFF USED	RATIO	AMB. TEMP	TEST DATE
1-10	ROOF	1% AFFF	60									
1-10	BUMPER	1% AFFF	60									
1-10	RF/BMP	1% AFFF	60									
1-10	HNDLNE	1% AFFF	60									

DATA FORM # 7
3% AFFF METERING TEST MATRIX
AND
DATA COLLECTION SHEET

TEST NO.	TURRET	AFFF TANK	DISPENSING TIME (sec)	WATER TANK START	WATER TANK END	AFFF TANK START	AFFF TANK END	WATER USED	AFFF USED	RATIO	AMB. TEMP	TEST DATE
1-10	ROOF	3% AFFF	60									
1-10	BUMPER	3% AFFF	60									
1-10	RF/BMP	3% AFFF	60									
1-10	HNDLNE	3% AFFF	60									

DATA FORM # 8
6% AFFF METERING TEST MATRIX
AND
DATA COLLECTION SHEET

TEST NO.	TURRET	AFFF TANK	DISPENSING TIME (sec)	WATER TANK START	WATER TANK END	AFFF TANK START	AFFF TANK END	WATER USED	AFFF USED	RATIO	AMB. TEMP	TEST DATE
1-10	ROOF	6% AFFF	60									
1-10	BUMPER	6% AFFF	60									
1-10	RF/BMP	6% AFFF	60									
1-10	HNDLNE	6% AFFF	60									

NOTE: RF/BMP = ROOF and BUMPER

DISTRIBUTION
ASC-TR-95-1004

Eglin AFB offices:

ASC/VXO 4
AFDTC/PA 1
WL/MNPM (Technical Library) 1

Defense Technical Information Center 2
Attn: DTIC-DDAC
8725 John J. Kingman Road
Ft Belvoir, VA 22060-6218

Wright Laboratory, Airbase Fire Protection and Crash Rescue Systems (WL/FIVCF) 1
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323

AFCESA/CEXF 1
Attn: Jim Hotell
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323

WR-ALC/LVV 1
Attn: Sharon Edwards
225 Ocmulgee Court
Robins AFB, GA 31098-1647

ANG/CEXF 1
3500 Fetchet Ave.
Andrews AFB, MD 20762-5157

HQ ACC/CEXF 1
Attn: Randy Caratachea
129 Andrews St., Suite 102
Langley AFB, VA 23665-2769

HQ AETC/CEOX 1
Attn: Billy Ferrell
266 F Street West
Randolph AFB, TX 78150-4321

HQ AFMC/CEOO 1
Attn: Jim McKay
4225 Logistic Ave., Suite 7
WPAFB, OH 45433-5739

HQ AFRES/CEXF 1
Attn: Donald Warner
155 Second Street
Robins AFB, GA 31098-1635

HQ AFSOC/CEF 1
Attn: CMSgt Marshall
204 Bennett Ave.
Hurlburt AFB, FL 32544-5270

HQ AFSPC/CEPX 1
Attn: Sandi Sanchez
150 Vandenberg St., Suite 1105
Petterson AFB, CO 80914-4150

HQ AMC/CEOO 1
Attn: Duane Morgan
507 A Street
Scott AFB, IL 62225-5022

HQ USAFA/CEF 1
Attn: Richard Duncan
9224 Airfield Drive
Air Force Academy, CO 80840-2080

HQ USAFE/RSIXF 1
Attn: Ray Porter
Unit 3050, Box 10
APO AE 09094-5010

Total Copies: 21